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GENERAL VIEW
OF THE
NATURAL HISTORY
OF THE
ATMOSPHERE,

&c. &c.

A

GENERAL VIEW

OF THE

NATURAL HISTORY

OF THE

ATMOSPHERE,

AND OF

ITS CONNECTION WITH THE SCIENCES OF

MEDICINE AND AGRICULTURE;

INCLUDING

AN ESSAY ON THE CAUSES OF

EPIDEMICAL DISEASES.

BY HENRY ROBERTSON, M. D.

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OF THE

NATURAL HISTORY

OF THE

ATMOSPHERE.

PART II.

CHAP. I.

OF THE CHEMICAL PROPERTIES OF THE ATMOSPHERE.

SECT. I.

THERE are many familiar operations which directly tend to prove, that the atmosphere is a compound fluid, independent of the aqueous vapour and other exhalations that are occasionally found mixed with it; and it is confirmed by those very processes, that its composition is entirely different from what was formerly entertained of its nature, by the most celebrated philosophers of antiquity; its constituent principles being at all times precise and defined.

A free access of the atmosphere is essentially necessary to animals and plants, for the performance of their functions; and the success of many processes of art, are entirely owing to its influence: but in every such instance, the atmosphere, as a compound fluid, is discovered to undergo a material change, and to become thereby unfit for the same or any similar operation.

When an animal is confined within a given portion of air, and all communication with the external atmosphere is precluded, a cessation of its functions very soon ensues; but this event takes place more or less readily, according to the quantity of air with which the animal is surrounded; and an animal of the hot-blooded kind, dies sooner when placed in such circumstances, than one of the amphibious or insect tribe. If a burning taper is placed in a similar situation, it is soon perceived to emit less light, its flame gradually decreasing, till it is completely extinguished. The air that remains in the vessel after such an experiment, is found to be highly deleterious to animal life: and, in like manner, that in which an animal has died, is found to be incapable of supporting combustion. Thus, similar changes are produced in the atmosphere, by processes which, in their effects, might have been expected to be widely opposite. When the air is examined after these experiments, it is discovered to differ considerably in its properties from the atmosphere of which it had formed a part; at the same time its aëriform state, together with its natural degree of transparency and elasticity, remain unaltered.

Changes somewhat similar are also produced on the atmosphere, by the oxidation of metals, the germination of seeds, and by acetous and other fermentations. But besides that the qualities of the air are found to suffer a considerable change in these processes, it is likewise discovered, that when the experiment is accurately conducted, by means of a pneumatic apparatus, a considerable diminution of its original quantity takes place. From these circumstances it appears, that the changes produced on the atmosphere, by living animals, matters in a state of combustion, the oxidation of metals, &c. are not solely effected in consequence of any thing being imparted to it, by the matters subjected to such experiments; on the contrary, it would seem, that the alteration is chiefly occasioned by the disappearance of a principle essential to the natural state of the atmosphere itself. In this way, the atmosphere is ascertained to be a compound body, which, when entire, is fitted for maintaining the most important phenomena of animal life, and is capable of producing considerable changes on matters in general; and that, in all these instances, it suffers a material alteration of its own properties.

As it is by the changes which the atmosphere effects on different bodies, that its intimate composition has been detected, the more simple the body is which is employed as a medium for analyzing this fluid, so much the more accurate will be the result of the examination, especially if the compound formed by the air, and the matter submitted to its action, does not assume the gaseous form, or is insoluble in the remaining portion of the atmosphere. There are many bodies that, even by modern chemical science, cannot be separated into different principles, and which are, therefore, held to be simple substances: the bases of many of the acids, and all the metals, belong to this class of matters, and, in general, the analysis of the atmosphere has been conducted by means of one or other of them. The oxidation of such metals as readily undergo that change, or the combustion of phosphorus in a quantity of air, give a result equally correct to that which is obtained by any other means.

About the time the composition of the atmosphere began to be made known, many erroneous opinions respecting its principles were prevalent, even amongst the most celebrated philosophers. To determine this question beyond the power of conjecture, the following experiment was performed by the very ingenious Lavoisier. He put a quantity of quicksilver into a retort, which was then closed in a way that all communication with the external air was precluded; the retort being next placed on a furnace, where it was kept for twelve days at a degree of heat nearly sufficient to cause the metal to boil: at the termination of this period, on examining its contents, he perceived, that the metal had suffered a complete alteration in its properties; it had acquired a red colour, become pulverulent, and had received an increase of bulk and weight; he likewise found, that the air which remained within the retort was considerably diminished in quantity, and had become unfit for the support of animal life, or the combustion of inflammable matters. In this way, he demonstrated one of the constituent principles of atmospheric air; and this, according to the preconceived theory of certain chemists, is denominated phlogisticated air, but more recently, since its nature and properties have been more fully ascertained, it is known by the name of nitrogen, azote, or azotic gas, on account of one of the principal compounds it forms, and from its remarkable deleterious effects on living animals. M. Lavoisier next took the red substance produced by the above experiment, and adapting receivers to the retort, for the purpose of containing any aërial product it might give out. It was in this manner again exposed to an high degree of heat, when he perceived that the colour of the substance faded, and that it decreased in bulk as the retort became hot; and at a red heat, it had resumed the form of fluid mercury; in the receiver, there was contained a portion of air that had been emitted from the metal during this part of the experiment, even better adapted than the atmosphere itself for maintaining combustion, and which seemed likewise more favourable for supporting animal life: this air exactly corresponded in quantity to the portion that had disappeared during the former part of the process, and was equal in weight to the increase of gravity the metal had then acquired; he was therefore at no loss to refer it to the source from whence it had been obtained. In this manner, the knowledge of another remarkable component principle of atmospheric air is acquired, formerly denominated dephlogisticated air, but which has been called vital air, pure air, oxygen, and oxygen gas, by later chemists, from its remarkable effects in the preservation of animal life, and the very general property it possesses of changing many of the simple bodies into compounds of an acid nature.

From these experiments, M. Lavoisier concluded, that the changes effected on the quicksilver during the first part of the process, were occasioned by its combination with the oxygen gas of the atmosphere; and that the alteration in the composition of the air which occurred in the course of the experiment, could not be imputed to the emission of any thing from the metal. The same ingenious philosopher discovered, that by mixing the two gases obtained in this manner, and in the proportions indicated by the above experiment, a fluid was formed, similar in its properties to common air,—a circumstance which affords a convincing proof, that atmospheric air is chiefly composed of those two gases. By the discovery of these fluids, Lavoisier was enabled to explain the theory of oxidation on principles very different from those which had been previously assumed. Contrary to the opinion of Beccher, Stahl, and their followers, he considers every metal as a simple uncompounded body, which being exposed to the atmosphere while at a certain temperature, its affinity for oxygen gas becomes thereby greater than the affinity that subsists between this fluid and nitrogen gas, in the composition of atmospheric air: by the combination of the metal in its heated state with the oxygen gas of the air, its increase of bulk, weight, and the other changes which it undergoes in its properties by being oxidated, are supposed to arise.

The correctness of this opinion is confirmed by daily experience, as well as by various other processes strictly analogical: it therefore supersedes the hypothesis of phlogiston, or any other theory that was maintained on gratuitous principles.

Besides the nitrogen and oxygen gases, there is also another gas, which, though it does not abound in so great proportion in the composition of the atmosphere as the others, it is perhaps equally permanent, and no less essential to its constitution. When a solution of lime

(lime-water) is exposed to the atmosphere, it is found, that the lime speedily acquires properties by which it is rendered insoluble in water; the solution is therefore gradually decomposed by the precipitation of the lime, which in this state is found to effervesce strongly by the addition of sulphuric acid: this effervescence is occasioned by the extrication of a gas which the lime has attracted from the atmosphere, and for which it has less affinity than for the sulphuric acid. From a more correct knowledge of the nature and properties of this gas, it is generally known by the name of carbonic acid gas: formerly it was denominated fixed air, aërial acid, &c. on account of its being frequently found in a fixed state in combination with other matters, and because of its abounding in the atmosphere.

This gas is regarded by many chemists rather as an adventitious matter, than as one essential in the composition of the atmosphere; though it is known to have been discovered in nearly equal proportion at the greatest heights, as in the stratum over the earth's surface. M. Saussure discovered it in the air over the top of the highest mountain of the Alps, though, in another instance, it could not be detected on the summit of Teneriffe; yet M. Humboldt ascertained its existence in air brought from a considerable elevation by means of a balloon. The same thing has been confirmed by Guy de

Lussac, it having been found, that a quantity of air taken by means of a balloon from an immense height, about 21,736 feet above the earth's surface, contained nearly the same proportions of component parts as in a similar quantity of air taken from one of the most frequented streets in Paris. But, considering that carbonic acid gas is at all times copiously evolved by many natural and artificial processes, it must occasionally happen, that greater quantities of it will be found, in certain situations, in the lower stratum of the air, while, in the higher regions, an uniform proportion of it may exist. But there is also another circumstance that causes an apparent variation in the quantities of carbonic acid gas existing in different situations of the atmosphere, which arises from a difference in the force of its attraction to the other principles of atmospheric air; thus, the quantity indicated by different tests rarely corresponds, and it even varies when the same test is differently prepared. Lavoisier and other accurate chemists have estimated its proportion in the atmosphere as being 1 to 100 parts; though Humboldt has since that time found, that the proportion of it varies from 0.005 to .001, and even, in some instances, as high as 15 or 18: on the other hand, Dalton never found it to exceed 1 or 0.002 parts.

The fluids of which atmospheric air is composed, being thus discovered to be nitrogen, oxygen, and carbonic acid gases, the proportion of each in forming its composition affords a subject of very interesting inquiry. By the experiments of Lavoisier already mentioned, he found, that 100 parts of atmospheric air consist of about 73 of nitrogen to about 27 parts of oxygen gas, and independent of the small proportion of carbonic acid stated above. And the same result was afforded by Dr Higgins' experiments on this subject. This calculation was universally admitted as correct, till the celebrated Berthollet published the result of some experiments he performed with a view to determine this question: he conducted the analysis of the atmosphere by means of phosphorus burning at the temperature of the air; and he thus discovered, that atmospheric air consists of only 22 parts of oxygen in the 100 parts. Humboldt found, that the quantity of oxygen in the atmosphere varies from 22 to 30 parts in 100. But it must be observed, that the experiments of Mr Davy, which seem to have been performed with unquestionable accuracy, give additional confirmation to the correctness of Lavoisier's opinion respecting the proportions of these gases. The apparent discordance in the result of the various experiments on this subject by different chemists, has seemingly originated from the different modes adopted for performing the analysis, and probably from want of attention in stating by what calculation the quantities were taken, whether by weight or measurement,—a circumstance essentially necessary to be made known, in determining the proportions of the gases which constitute the atmosphere. When the specific gravities of the decomposed fluids are taken for the standard, in attempting to determine this question, it is found, that 100 parts of atmospheric air consist of 26 of oxygen gas, 73 of nitrogen gas, and 1 of carbonic acid gas; and by measuring their proportions, they are found to be only 22 of oxygen gas, 77 of azotic gas, and 1 of carbonic acid. Scheele's statement of the proportion of the constituent gases of the atmosphere, does not materially differ from that of Lavoisier, making every allowance for the difference of the tests or eudiometers they employed; and it seems probable, that the proportions of the principles of atmospheric air, as indicated by them, approach nearly to the truth. There is likewise another cause, which produces a difference in the result of the proportions of the constituent gases of the atmosphere: this arises from the different force of attraction subsisting between the tests employed in the analysis, with either of its constituent gases. Thus, phosphorus, or the sulphuret of potash, combines with .021 or .022 parts of oxygen gas, when burning in the atmosphere; metals in general do not combine with so large a proportion during their oxidation; though some of them appear to unite with even a greater quantity; on the other hand, sulphur, when in a state of combustion, only unites with about an eighth of oxygen. Dr Wilson observes, but from what experiments we are unacquainted, "that the air of all climates is more dephlogisticated, (contains more oxygen gas) in proportion as they become colder." At the summit of Chimborazo, Humboldt found the atmosphere only contains 0.20 parts of oxygen gas; but the discordance of his experiments on this subject, is most probably owing to the nature of the test he employed (nitric oxide gas), which is scarcely susceptible of giving an invariable result, even when prepared with the greatest care. However, Dr Chisholm mentions, in his Treatise on the Malignant Fever of the West Indies, that the quantity of oxygen gas at all times existing in the atmosphere of those climates, is much greater than has ever been detected in the air of more temperate latitudes: he says, that a friend of his had often found the proportion so high as 60 in the 100 parts; and on this circumstance, the Doctor lays the foundation of a very ingenious theory, in explanation of the diseases of that country. But we have to oppose to this fact, the statements already given of the analysis of the atmosphere by Berthollet, Guy Lussac, and Humboldt: and likewise in a quantity of common air brought from the coast of Guinea, the proportions of these gases were not found to differ from those of the air in Britain, as ascertained by the accurate examination of Dr Beddoes and Mr Davy.

The following are the proportions of the constituent gases of the atmosphere, according to the experiments of different philosophers.

Lavoisier,	27 oxygen by weight, and 73 azote.		
Sennebier,	25		
Priestley,	20	25	
Humboldt,	20	23	28
Cavendish,	20		

And perhaps the principles of the atmosphere may be, according to these experiments, in the following proportions :

Oxygen,	21	by measure,	or	23	32 by weight.
Azote,	75	5	-	75	55
Vapour,	1	42	-	1	23
Carbonic acid,	0	08	-	0	10

From these facts, it is to be remarked, that the precise quantities of the constituent gases of the atmosphere is probably the same every where, though their proportions have not perhaps been ascertained with minute accuracy. We shall next attend to the most common methods that have been employed in determining the proportions of the principles of the atmosphere; in this investigation, it will be made appear, that not only the difference of the tests, but likewise the condition of the atmosphere itself, will occasionally produce variations in this analysis.

SECT. II.

OF EUDIOMETRY.

EVERY substance that combines with any of the permanent gases of the atmosphere may be considered as an eudiometer, or test for ascertaining its purity. The matters commonly used for this purpose, having been most frequently employed with a view to ascertain the proportions of its permanent principles, therefore, those matters which most speedily combine with either of its constituent gases, and absorb the greatest proportion of them, have been preferred.

The hydro-sulphuret of potash has its properties completely changed by exposure to the atmosphere; the oxygen gas of the air combining with the sulphur in the compound, converts it into sulphuric acid, and the mixture then becomes sulphuret of potash. Hence it will appear obvious, that the proportion of the atmosphere will be diminished according to the quantity of oxygen gas which the hydro-sulphuret absorbs. Sulphuric acid is supposed in general to contain 1 of oxygen to nearly 6 of sulphur. The principal objections to this method, is the length of time necessary to complete the experiment; besides, a portion of hydrogen gas is frequently emitted by the test;

and it has likewise been found to absorb some of the nitrogen gas of the atmosphere. This was the eudiometer employed by Scheele; and he discovered by this means, that the oxygen of the atmosphere amounts to .027 parts. It has been found, that any of the other hydro-sulphurets possesses similar properties; and De Marti has ascertained, that when they are recently prepared, and saturated with azotic gas, that the correctness of the result which they afford may be depended upon: he prefers this method as it is easily performed, and not otherwise liable to variations. The experiment is recommended to be conducted by means of a graduated glass tube, of about 10 inches in length, and one-third of an inch in diameter, closed at one of the ends. This being filled with common air, is introduced into a bottle placed on a pneumatic trough, capable of containing three or four times the measure of the air introduced; which bottle, having been previously filled with liquid sulphuret of lime, impregnated with azotic gas, and being then accurately shut by means of a ground stopper, it must be agitated for a few minutes; the graduated phial being then filled with water, must have the air transferred into it from the bottle, and according to the decrease of its bulk, the quantity of oxygen gas that has been absorbed, will be indicated by the degrees marked on the phial. In this way De Marti found, that the oxygen gas contained in the atmosphere was only in the proportion of 0.22 parts. It is however to be remarked, that even with the improvements he suggests, it is difficult to conduct the experiment correctly, or even to prevent the absorption or emission of other gases, during the alteration of the properties of the sulphuret, while it unites with the oxygen gas of the air. Dr Hope has accordingly improved the manner of performing this experiment, by a very neat and ingenious apparatus. It consists in agitating the air to be analyzed with the test, by means of two small bottles connected together. The phial which contains the test is of about three inches in length, and two in diameter, having a neck with a stopper near to its under part. It has also a neck in its upper part, fitted to receive the neck of a bottle of the same diameter, but of three times the length of the former, and which contains the air to be operated on. This is not only a more expeditious method, but the analysis is supposed to be rendered by this means more perfect. See Nicholson's Journal, vol. vi. p. 210.

Mr Davy proposes a substance for eudiometrical purposes, which acts on the principles of the atmosphere in a manner similar to the above; but it is also liable to the same objections. He uses a solution of the muriate or sulphate of iron in water, previously saturated with nitrogen gas. A small graduated tube, such as that proposed by De Marti, is to be filled with a portion of the air intended for examination. It must be conveyed into the solution, and agitated through it for a few minutes; and the quantity of air that disappears, indicates the proportion of oxygen gas contained in the composition of the atmosphere. Mr Davy cautions against one source of inaccuracy from this method. Having observed, that after the absorption of the oxygen gas, the mixture frequently emits a portion of air, which considerably alters the result; the period of greatest absorption should on that account be marked, as denoting the exact quantity of oxygen gas absorbed. The result afforded by this experiment shews, that the atmosphere contains only 0.21 parts of oxygen gas. It must however be remarked, that every eudiometer of a compound nature, whose principles undergo so great changes during the course of the experiment, as in either of the above instances, can never be regarded as affording a rigidly correct analysis of the subject; nor can they be used but by those who are in the daily habits of performing the nicest experiments.

The method of ascertaining the purity of the atmosphere, by the nitric oxide gas, is perhaps the original eudiometer that was suggested. Dr Priestley performed the experiment by mixing certain proportions of atmospheric air and nitric oxide gas, by means of a pneumatic trough: the diminution of bulk occasioned by the mixture, shewed the quantity of oxygen gas that was absorbed, and of course the proportion of this gas in the atmosphere; the nitric acid formed by the combination being absorbed by the water: but when the analysis of the atmosphere is performed in this manner, it is neither so convenient, nor so susceptible of correctness as it necessarily should be, even with the improvements of Dr Falconer, Fontana, Ingenhouz, Humboldt, and others. When Ingenhouz employed this gas as an eudiometer, he discovered, that the proportion of oxygen gas in the atmosphere amounted to 0.27 parts. A similar proportion was obtained by others: but Humboldt found, that by this means the quantity of oxygen gas varies from 0.22 to 0.30 parts, though he bestowed every attention in performing the experiment, and was especially careful in preparing the nitric oxide gas. That it may be obtained pure for this purpose, Humboldt recommends that it should be prepared from nitric acid of density 1.170, a quantity of azotic gas being usually found mixed with it, when procured by means of a stronger acid; it is recommended to wash it by passing it through pure water, and it is afterwards further purified from any accidental mixture of nitrogen gas, by exposing it to a solution of sulphate of iron. A certain portion of nitric oxide gas thus purified is transferred into a graduated glass jar, containing a specified quantity of common air, placed over the shelf of a pneumatic trough: the nitric acid, which is in this way regenerated, is immediately dissolved in the water, which rises in the jar, and thus indicates the quantity of oxygen gas that has been absorbed. In performing this experiment, great care must be bestowed in mixing the two gases; it must be done gradually, and the vessel frequently shaken. Dr Priestley, however, observes, that even variations are apt to arise from the too slow or otherwise incautious manner of performing this part of the experiment; the vessels in which the mixture is performed, must be quite uniform, and not too tall, so that the combination may take place in every portion of the mixture at the same time. There may also be a source of error by the combination of the nitric oxide gas with the oxygen of the atmosphere: this arises in consequence of a considerable increase of temperature taking place by the union of these gases, which induces a corresponding increase of the volume of the air under examination. For this reason, it is necessary, in every instance where nitric oxide gas is used as a test of the purity of the atmosphere, to allow the contents of the jar to resume the temperature it had at the commencement of the experiment, before the calculation should be made.

It has been suggested by M. Volta, to combine hydrogen gas with the oxygen gas contained in a portion of the atmosphere, as a mean well fitted to determine the proportion of that fluid existing in it: his method is to pass the electric spark through a graduated glass tube, filled with certain proportions of hydrogen gas and atmospheric air; in this way the mixture is set on fire. As the hydrogen gas unites with the oxygen gas of the air, a quantity of water is generated; and, as in the former instances, the diminution of the air in the tube affords the result. Nevertheless, there seems to be many objections to this test; the experiment is in itself dangerous, if not conducted with great care; besides that it is difficult to be performed with that precision which is necessary; the water which is formed must be occasionally either wholly or partially converted into vapour, from the intensity of the heat during the combustion of the hydrogen gas; and a considerable dilatation of the gases must thereby take place. But another source of error must arise from the difficulty of knowing the quantity of hydrogen gas that is necessary to combine with the oxygen gas contained in the atmospheric air under examination: if the proportion operated upon happens to be too small, the whole of the oxygen gas in that case will not be absorbed; if too great a portion of hydrogen gas is used, of course an error will likewise arise from a quantity of it remaining uncombined; or by uniting with the azotic gas, and forming a compound of a different nature, it will thereby considerably alter the result of the experiment. Upon the whole, this way of extracting the oxygen gas from a definite portion of common air, is apparently more incapable of precision than any other method that has been suggested for performing the analysis. At the same time, we have to remark, that it has been recommended by the celebrated Berthollet, as the method most susceptible of perfection.

The analysis of the atmosphere at present most generally in use, is by means of phosphorus: this is more convenient than any other, and the result it affords is equally correct. It has accordingly been used in experiments of this kind by every chemist. When phosphorus is used in a state of rapid combustion, the great increase of temperature which in that case takes place in the air under examination, must cause considerable irregularities in the result; besides, azotic gas has the power of dissolving a portion of the phosphorus, and when its temperature is augmented, probably its solvent power is proportionally increased. The slow combustion of this substance, is the way which is now preferred in eudiometrical experiments, when the result is intended to be precise. For this purpose, a slender cylinder of phosphorus, fixed to a glass rod, is introduced into a graduated glass vessel, filled with atmospheric air, which is then inverted over mercury or water; as the phosphorus burns at the temperature of the air, a dusky appearance, succeeded by distinct white fumes, begin to be perceived soon after the commencement of the experiment; these increasing, fill the vessel completely. This milkiness continues, while any portion of the phosphorus and oxygen remain suspended in the azotic gas; but as soon as the whole is saturated, the contents of the jar soon become transparent, from the precipitation of the phosphoric acid formed in this manner; the proportion of oxygen gas necessary to form this acid being about 1½ to 1 of phosphorus, or amounting to 60 parts in 100 of phosphoric acid. The quantity of oxygen gas which disappears in this way is indicated by the height which the water rises in the jar, after the whole apparatus has been allowed to resume the temperature it had at the commencement of the experiment. In this manner, the proportion of oxygen gas discovered to exist in the atmosphere is .022 parts, after deducting the increase of bulk which the azotic part of the atmosphere acquires by retaining a portion of phosphorus in solution. Berthollet has calculated the dilatation of the remaining gas to be, from this cause alone, one-fortieth part of the whole air employed; and by making this deduction, the result of the experiment is supposed to be correct. With regard to the eudiometers we have mentioned, there are none in which the indications exactly correspond with each other. This seems to arise from a difference in the nature of the tests employed to detect the different constituent gases of the atmosphere. Phosphorus has even been found mixed with impurities after the greatest attention in preparing it; and when compound substances are employed, it must be still more difficult to guard against the introduction of foreign matters, which must have a very considerable effect in varying the result of the experiment. But, besides the errors that are apt to arise in eudiometrical experiments from the nature of the tests employed, variations must likewise occasionally happen, in consequence of a difference in the condition of the atmosphere itself. An uniformity in the gravity, temperature, quantity of vapour, and other matters contained in this fluid, must be carefully attended to, in performing experiments to determine the proportions of its constituent gases. The gravity of the air can always be ascertained by means of the barometer; but whenever a portion of it is confined in a vessel, placed over the trough of a pneumatic apparatus, it will have its density increased, and consequently its specific gravity varied, in proportion to the density of the medium employed to exclude the communication of the external air. Unless the air contained in the jar has its lower surface exactly level with the surface of the liquid with which the trough is filled, every variation from this line must increase or diminish its density in a corresponding degree. Though, at the commencement of the experiment, any error that might arise from this source may be guarded against, yet there is not even a possibility of preventing an increase in the density of the air remaining in the jar after the operation; and the density will be increased in proportion to the height at which the water or mercury rises within the vessel.

The variations occasioned by a difference of temperature in the atmosphere, rarely produce so great anomalies in eudiometrical experiments as those occasioned by a difference of its gravity, as a constant uniformity of temperature can be more steadily preserved during the analysis of a portion of it; otherwise, the great power of heat in altering the volume of all fluid bodies would cause a considerable inaccuracy in the result of the experiment. But a difference in the quantity of vapour it contains probably leads to greater variations in the decision of the experiment, than what arises either from its density or temperature; and this source of error is perhaps more difficult to be corrected.

Air containing a considerable portion of elastic vapour, will not afford to any test a quantity of oxygen gas equal to what may be extracted from the same measure of air holding less vapour; nay, in many cases, there is reason to think, that the vapour will act upon the eudiometer employed. In this way, it may vary the decision, by altering the properties of the test, or by uniting with it, remain mixed with the nitrogen gas. Before a series of experiments that are meant to be minutely correct should be commenced on the analysis of the atmosphere, in every instance, the portion to be operated upon should be previously freed as much as possible from humidity and other extraneous matters. For this purpose, it should be passed repeatedly through lime-water, which will at the same time absorb the fixed air contained in it, and, in other respects, will have the same effect as a solvent as water alone. It may be proper to expose it afterwards to a considerable degree of cold, over a quantity of caustic potash; or it may be exposed to the influence of each of these matters alternately, so long as may be judged necessary. In this manner, most of its superfluous vapour will be extracted from it; but it will be rendered still more dry, by passing electric sparks through the vessel containing it, while it stands over caustic alkali or any other matter that has a strong attraction for water. By allowing the air thus purified to remain for some time undisturbed, it will soon regain the temperature of the surrounding atmosphere; and a comparison of its density with the atmosphere of which it had formed a part may be determined, by calculating the difference between an equal portion of it and of air thus freed from the admixture of foreign matters.

These seem to be the most prominent sources from which anomalies in the result of all eudiometrical experiments proceed. The difficulties will be perceived to originate from different causes; and till means be discovered to obviate these, a precise indication of the proportions of the constituent gases of the atmosphere cannot be expected. At the same time, it seems probable, that the experiments of M. Lavoisier, Scheele, and Davy, may be considered as accurate as the subject will admit.

SECT. III.

OF COMBUSTION.

Besides the oxygen, nitrogen, and carbonic acid gases, there are other principles said to exist permanently in the atmosphere, and which are presumed to be the media by which the bases of these fluids assume the gaseous condition. When a bit of phosphorus is heated to a few degrees above the ordinary temperature of the atmosphere, it begins to be inflamed; and if, in that state, it be conveyed into a vessel containing common air, a very brilliant light continues to be emitted, at the same time the temperature of the air becomes greatly augmented: these appearances constitute the phenomena of combustion. When the combustion of the phosphorus is terminated, a considerable diminution of the quantity of the air is perceived, by the water having risen within the vessel, if it has been placed in a pneumatic trough, and the portion that remains will be found to consist principally of nitrogen gas, and in every other respect to agree in its properties with the air that remains after the oxidation of a metal, or any other eudiometrical experiment. The properties of the phosphorus suffer likewise a great alteration; it thereby completely loses its quality as an inflammable body, and its affinities for other matters are no longer the same. These effects are owing to the combination of the phosphorus with the oxygen contained in the air. It is to be observed in favour of this opinion, that the capacity of gaseous bodies for heat, and according to some, for light also, is greater, and therefore the absolute quantities of those matters contained in them are more, than what are observed in substances of greater density: it is therefore evident, that, as a considerable quantity both of heat and light enter into the composition of atmospheric air, and which are essentially necessary to its constitution; it follows of consequence, that the peculiar appearances which characterize the process of combustion must be owing, in a considerable degree, to the decomposition of the atmosphere; the heat and light which are necessary in its compound or gaseous state, being extricated when either of its constituent gases is separated, by entering into new combinations with any other body. But although this theory is extremely plausible, and is supported with much ingenuity, there are many difficulties in the process, which it by no means explains. However, there can be no doubt, that heat and light do form component parts of atmospheric air: and as the electrical state of the atmosphere suffers also a considerable change by combustion, and in other analogous processes, there is every reason to imagine, that it also forms a necessary part of the same compound. The existence of heat and light, as component parts of atmospheric air, is likewise distinctly pointed out by experiment, even when the separation of its principles do not take place. Thus, in an air-gun, so contrived that what passes in its interior can be easily seen; when the air is very rapidly condensed in the chamber, a considerable rise of temperature takes place, at the same time a vivid flash of lightning is perceived. See Nicholson's Journal, 8vo, vol. ix. p. 302.

The foregoing opinion respecting the cause of combustion was originally proposed by Lavoisier. He imagined, that the heat and light emitted during that process originates from the decomposition of the atmosphere alone; and he supposed this theory was firmly established, by having discovered, " that in every case of combustion, oxygen combines with the burning body." But although matters do not burn unless oxygen gas be present, either in a pure state, or combined, as in atmospherical air, &c. it is to be observed, that this gas unites with many substances during the decomposition of the atmosphere where light is not emitted, which could not take place were this theory correct; and even in such instances, the rise of temperature is dubious. Besides, were the heat and light which constitute the phenomena of combustion to originate solely from the decomposition of the atmosphere, all inflammable matters, at a certain degree of temperature, however different in their natures, would be uniformly accompanied by the evolution of heat and light; neither would there be any variety in the intensity of the temperature of matters in a state of combustion, or in the appearance of the coloured rays, provided that the same quantity of oxygen gas has disappeared from the atmosphere during the operation. But this is widely different from the true state of the case; for not only do the luminous rays differ, according to the nature of the combustible body, but the quantity of caloric also varies, and is even in some instances greatest, when but a comparatively small portion of oxygen gas combines with the burning matter. Besides, were the heat and light which constitute the appearances of combustion entirely owing to the decomposition of atmospherical air, this process could never take place, except when oxygen is present in a gaseous state: nevertheless, in many instances, the same appearances are found to arise from the mixture of an inflammable body with some substance where the oxygen is in a fixed state; thus, if nitric acid be poured upon an essential oil, the oil immediately takes fire, and the phenomena of combustion become extremely vivid. Gunpowder may be fired within an exhausted receiver; in this instance, the oxygen is fixed in the nitrate of potash, which forms a part of the composition of the inflammable body. In a similar way, phosphorus may even be made to burn under water, by the addition of a small portion of the oxymuriate of potash, with a few drops of sulphuric acid being poured over it. It has been already remarked, in the observations premised on the nature of light, that it is frequently emitted from matters where there is no rise of temperature; and it is found, that both heat and light are extricated from substances where there can be no suspicion that oxygen forms any part of their composition. Light, and probably heat also, is emitted by the friction of two quartz stones; and this takes place even when the experiment is performed under water. The sulphuret of iron, which does not contain oxygen gas, emits both caloric and light, when previously heated a few degrees above the temperature of the air; and the experiment succeeds equally well when performed in the exhausted receiver of an air-pump as in the open air. In this class of exceptions to the above-mentioned theory, the various kinds of pyropheri must be likewise included. But there is still an objection, no less powerful than those already stated, against the implicit belief of the above opinion on this subject. It is ascertained, that in instances where oxygen gas forms a much larger proportion of certain matters than the quantity of it in the formation of atmospherical air, and also where these compounds exist in the state of gas, as in carbonic acid, watery vapour, &c. that so far from maintaining combustion, burning bodies are actually extinguished when immersed in them. Although there is a greater proportion of oxygen in the composition of nitric oxide gas than in that of the atmosphere, where its other principles are similar to that fluid, yet it does not support combustion, except in matters of the most inflammable nature, and which must be previously heated to an high temperature, before that process takes place.

These and similar objections to the above theory, have been attempted by several chemists to be explained in such a manner, as to lessen their force in invalidating the general doctrine. Professor Brugnatelli imagines, that these exceptions could admit of an interpretation, which, were it established with the evidence of facts, would even go far to confirm the original theory of Lavoisier on this subject. He supposes, that during combustion, the oxygen gas in some instances combines with bodies, still united with different proportions of heat and light; when it unites with them in this condition, he calls it thermoxygen; but when it combines with the inflammable matter without retaining any portion of these, he continues the common name of oxygen. He supposes, that aëriform and liquid matters contain thermoxygen; he likewise thinks that it exists in a similar state in the composition of some solid matters; all metals unite with thermoxygen only, while all substances that acquire acid properties during combustion, unite with oxygen simply. However, it does not appear, that all metals enter into union with oxygen, as combined with a peculiar state of light and heat: many substances of that class of matters are extremely combustible, and are always converted into an acid during that process; these must therefore combine with oxygen in its most simple form. But even admitting the accuracy of this ingenious explanation, it does not appear, that Lavoisier's doctrine would be indisputably established by it; and the general objections to his theory above stated may be likewise opposed to this: but as the data on which it is founded are entirely gratuitous, any minute discussion of its validity would be on that account superfluous.

Although it has been shown, that all bodies have a capacity for the matter of heat, and of light also, this quality is never, perhaps, exactly the same in any two different substances, even of a similar form of matter. This property must be likewise continually varying, in consequence of the combinations of matters with each other, and their consequent changes of form. Indeed, there are many facts which show, that caloric bears different degrees of affinity to other bodies, similarly to what takes place between matters in general.

It is in consequence of the capacities of bodies for heat being different, in their simple state, to what they possess when combined, that a considerable increase of temperature is occasionally produced by the admixture of various substances. And in the same way, great degrees of cold are frequently generated. It has been also shown, that light unites with some bodies in preference to others; that certain substances even show a greater attraction for one primitive ray than another; and that this property varies by combination or admixture of different matters, and distinctly indicates the resemblance of the properties of light in this respect to the attractions evinced between all other descriptions of matter. It is to this cause, that different inflammable matters are presumed to afford a variety in the intensity of the degree of heat and light emitted during their combustion, and that the colour of the flame is likewise various in different bodies: thus, spirit of wine emits a blue or indigo coloured flame; charcoal, in burning, gives out a red light, sulphur a pale blue, and phosphorus a bright rose colour. For matters which in their entire state have but a weak capacity for heat, and attract but one or two of the primitive rays of light, cannot give out so much of either in their decomposition, as another body which has a greater capacity for heat, and which is combined with all the primitive rays. It is to be imputed to the above circumstance also, that many compound inflammable substances produce all the phenomena of combustion, during a change of their most obvious chemical qualities. In this way, it is explained, why solid inflammable matters do not in general afford so intense a degree of heat in burning as those that are liquid, which are also exceeded in the quantity of heat extricated by the combustion of a gaseous body. This is exemplified in the burning of pit-coal, oil of turpentine, and hydrogen gas. In the same way, it is to be observed, that the quantity of light emitted during combustion is not always in proportion to the intensity of heat given out at the same time; on the contrary, this seems frequently to appear in reverse proportion; thus, the quantity of light given out from solid matters when burning is greatest, it is less in liquids, and least of all in the combustion of the gases. From these circumstances, we conclude, that a great proportion of the heat and light also, which is emitted in the process of combustion, is afforded by the decomposition of the inflammable body itself. It is likewise owing to the general distribution of heat and light, and the peculiar affinities of different matters for these fluids, that substances which do not contain oxygen either in a fixed or gaseous state produce, in many instances, phenomena similar to those given out by matters in a state of combustion. Phosphorescent bodies, pyrophori, the light emitted by the friction of quartz stones, and the appearances caused by the sulphate of iron, are entirely owing to this circumstance.

The above explanation respecting the sources of heat and light emitted during combustion, seem to apply, and are even elucidated in every variety of this process: thus, in deflagration, where the sudden evolution of the phenomena constituting combustion are accompanied with a considerable noise, by the concussion of the surrounding air, in consequence of the rapidity with which the products assume the elastic form; the report or noise thus occasioned by their extrication, is proportionally increased, according to the resistance given to their expansion. This circumstance is exemplified in discharging pieces of ordnance, &c. The process of deflagration or detonation is demonstrated by burning a mixture of saltpetre and charcoal, or by striking smartly a grain or two of phosphorus, loosely mixed with about as much of the oxymuriate of potash. In this case, the heat that is suddenly generated, probably in consequence of an alteration in the density of the materials, is sufficient to overcome the aggregate affinity of their particles, and thereby favours the union of the oxygen gas extricated from the salt with the phosphorus, whereby phosphoric acid is formed; the superfluous muriatic acid flying off in the form of vapour; the phenomenon of combustion being always more vivid in proportion to the rapidity with which the oxygen combines with the burning body.

On these principles, the following is supposed to afford a concise view of the theory of combustion:—The heat and light emitted during this process, principally originate in consequence of the decomposition of the inflammable body by the action of the air; the combinations which are thereby formed, having a less capacity for heat and light, than either the air or inflammable substance, in their entire state. A quantity of these fluids is thereby liberated, which, from their repellent properties, fly off in all directions, uniting with the surrounding bodies; and it is probably in this way we so frequently find, that the products of combustion, although containing a considerable portion of oxygen gas, are nevertheless totally unfit for supporting this process in other matters; and the products are perhaps proportionally less fitted for this purpose, according to the intensity of heat and light emitted during their formation: this seems to be exemplified in the matters produced during the burning of hydrogen gas, oil, or charcoal, with oxygen gas. In confirmation of the above opinion, it is constantly observed, that, in general, the intensity of heat given out during combustion bears a proportion to the density of the product that is formed: when it is gaseous, the caloric emitted is always less than when it is liquid; in this respect, the process of combustion bears a resemblance to the emission of caloric by the admixtion of different matters, as in the instances already given of the slaking of lime, in the mixtion of sulphuric acid and water, &c.

This theory of combustion accords better with the variations of the process than that originally proposed by Lavoisier, and affords a more distinct explanation of the whole phenomena; and the existence of the constituent gases in the atmosphere, combined with a portion of heat and light, is no less distinctly pointed out. A more complete elucidation of this opinion may be found very fully discussed in the work of Dr Crawford on Animal Heat, to which we therefore refer.

SECT. IV.

OF THE SUBSTANCES FORMED BY THE COMBINATIONS OF OXYGEN AND AZOTIC GASES.

The compounds of oxygen and azotic gases that are known, besides atmospheric air, are nitric acid, nitrous oxide gas, and nitric oxide gas; the former is commonly met with in the liquid state; the others are permanently aëriform, and the liquid condition of the first arises, in consequence of its great affinity for water: it is therefore manifest, that all the compounds of these gases naturally exist in the state of air. It is only meant to give an outline of the general properties of these substances, in order to mark their affinity to the subject in question. When 87 parts of oxygen and 13 of nitrogen gases are mixed in a glass jar, and the electric spark passed through them, a quantity of nitric acid is in this manner produced. But Mr Davy discovered, that pure nitric acid contains 1 of azotic gas, to 2.3 of oxygen gas; it always exists in the form of air, at the usual temperature of the atmosphere: 100 cubic inches of it weight 76 grains; and it may be analyzed into its constituent gases, by passing it through a red-hot porcelain tube. But nitric acid is most usually procured, by distilling it from the nitrate of potash; by adding to that salt a quantity of sulphuric acid, which having a greater affinity for the potash than what is possessed by the nitric acid, it unites with the alkali, allowing the acid to escape in the form of vapour. Nitric acid, combined with potash, is found to exist abundantly in nature: it has even been discovered in the analysis of some plants: it abounds copiously in masses of decayed animal and vegetable matters, when mixed with rubbish containing any alkaline substance, as in the sweepings of stables: indeed it seems to be generated in every situation which has been much frequented by cattle, and its principles are always evolved in the putrefactive process of animal and vegetable matters.

The next compound of the gases, which compose the basis of the atmosphere, is the nitrous oxide gas, or the gaseous oxide of nitre by Mr Davy; it is always found in an aëriform state: it was originally detected by Dr Priestley, in the course of his experiments on the different kinds of air; but we are chiefly indebted to the associated Dutch chemists, and in a particular manner to Mr Davy, for an accurate knowledge of its properties. It is sparingly evolved during the solution of metallic oxides in nitric acid, but it is then always contaminated with the presence of another gaseous substance. Mr Davy found, that it could be procured most copiously, and freed from the admixture of any foreign gas, by exposing a quantity of the nitrate of ammonia, to a degree of heat above 360° and less than 500° of Fahrenheit. The gas which then comes over is colourless, elastic, and possessed of the mechanical properties of common air; it is soluble in water, in a certain degree, to which it imparts a sweetish taste; when it is respired, it communicates a peculiarly faint smell, and a singularly agreeable state of intoxication is thereby induced; in this respect it resembles some of the diffusible stimuli of the most fugitive kind: this effect is peculiar to this gas, and although this is not exactly the same in every individual, still it is very remarkable in producing the most pleasurable sensations, accompanied with an uncommonly rapid succession of agreeable ideas, and a considerable propensity to muscular exertion. Its specific gravity is greater than that of atmospherical air: 100 cubic inches of it weigh 50.1 grains, being to the former as 161 to 100. Mr Davy has ascertained, that its principles are combined in the proportion of 36.70 of oxygen gas, with 63.30 of nitrogen gas, in the 100 parts: thermometer 55°, barometer 30 inches. The same ingenious chemist supposes it to be the most intimate combination that is formed by the union of these fluids.

Nitrous oxide gas supports animal and vegetable life, longer than any other artificial air, with the exception of oxygen gas; it also maintains combustion in the most vivid manner, but it is not decomposed by inflammable substances, unless they be previously heated to a high temperature: it is emitted from its solution in water, by boiling. Animals do not live in this gas many minutes; and in such as have been dissected after the experiment, similar appearances have been discovered in the lungs, as are met with in those destroyed by breathing oxygen gas; these being, in such instances, the consequences of inflammation. Nitrous oxide gas is decomposed by heat, and by the continued action of electricity.

There is another gaseous body, composed of certain proportions of oxygen and nitrogen gases, and which differs considerably in its properties from any of the other compounds of these fluids. It was originally discovered by Dr Hales, but it is to the labours of Dr Priestley, that we are acquainted with its affinities and other properties. He named it nitrous gas; at present it is denominated technically nitric oxide gas, to distinguish it from the last-mentioned compound. It is most copiously obtained, by collecting the gas which arises during the solution of copper in nitric acid. It is colourless and elastic, like atmospheric air, but of greater specific gravity, though not so heavy as the nitrous oxide gas. According to Mr Davy, it is composed of 55.95 of oxygen gas, and 44.05 of nitrogen gas: 100 cubic inches of it weigh 34 grains. Like the former gas, it combines with several of the acids, as the sulphuric, nitric, &c. on whose properties it effects a considerable change. Its union with the nitric acid, forms the compound known by the name of nitrous acid. Living animals are instantly suffocated on being immersed in it, and it only supports combustion in matters of the most inflammable nature, previously heated to a very high degree. It is absorbed by water, but it does not communicate to it an acid quality: it greedily attracts oxygen gas, when exposed to the atmosphere, with which it forms nitric acid; and it is in consequence of this property, that it was originally proposed by Dr Priestley as an eudiometer. This gas has been decomposed by electricity, although not by the direct application of heat.

With regard to the compounds in general, which are formed by oxygen and azotic gases, it has been observed, that nitrous oxide is the most intimate combination of those matters; it enjoys properties very different from any of the other compounds, and is of a greater specific gravity next to that of nitric acid, though the proportion of oxygen gas it contains be much less than that of the nitric oxide: this last gas is supposed to be a more intimate union of these principles, than their combination in atmospheric air; its specific gravity is not considerably greater than that fluid, although its proportion of oxygen gas be nearly double. There is another remarkable circumstance to be attended to, in regard to these compounds, that although the nitric oxide and nitrous oxide gases, are formed of a much greater proportion of oxygen gas, than what enters into the composition of atmospherical air; still they do not answer the purposes of combustion so well, nor do they support animal life in a degree corresponding to the quantity of oxygen gas they contain. Indeed, the very opposite conclusion is to be inferred; for in all the compounds of these gases, those containing most oxygen gas are found more highly deleterious to animal life, and this seemingly in proportion to the quantity of oxygen they hold in combination.—Having gone over the compounds formed by the constituent gases of the atmosphere, an examination of the properties possessed by those matters themselves comes next to be investigated.

SECT. V.

OF OXYGEN GAS.

OXYGEN GAS was first discovered by Dr Priestley on the 1st of August 1772, nearly twelve months prior to the period when Mr Scheele made known the existence of the same fluid.

Oxygen gas is never found in an uncombined state; it abounds most copiously in the atmosphere, but there are many other matters from which it can be more conveniently procured, as there is no substance known, which unites readily with the azotic portion of that compound. Oxygen gas enters into the composition of an immense variety of matters; perhaps every substance possessed of acid qualities contains a portion of it; and it is most readily obtained from most of the nitrates, as the nitrate of potash, of mercury, and of silver, &c. It has been shewn to be the principal agent in the process of oxidation; it is therefore frequently procured from metallic oxides, as the red oxide of lead, or the black oxide of manganese: it is likewise emitted in considerable quantity by plants, when exposed to the influence of the sun; it may therefore be procured by immersing the leaves of plants in water, and exposing them to the solar light; but the following are the methods most generally employed for procuring it in most abundant quantity.

If a quantity of the nitrate of potash (common nitre) be put into an earthen retort, and then placed upon the fire, the oxygen in its composition will be thereby extricated in the form of gas, as the contents of the retort become heated; and it may be received into jars arranged in the shelf of a pneumatic apparatus. In this way the oxygen gas is obtained tolerably pure, provided the heat applied has not been too great, or continued too long: in that case a portion of nitrogen gas of the acid frequently passes over with it, and this takes place whenever any of the nitrates are used for this purpose, if this caution be not attended to.

Mr Scheele discovered, that the black oxide of manganese treated in the same way, gives out oxygen gas in its purest state: but the most expeditious way of procuring it from this substance, and by which its purity is not at all impaired, is to have the oxide previously reduced to a powder; and putting it into a glass retort, as much sulphuric acid as is sufficient to cover it is then to be poured over the mass, by applying a moderate heat to the mixture by means of an Argand's lamp; a quantity of oxygen gas passes over as soon as the contents of the retort acquires a sufficient temperature.

Oxygen gas is colourless, inodorous, and possessed of the common mechanical properties of atmospherical air: it is much heavier than an equal bulk of the atmosphere, its specific gravity to that of water being as 0.00135 to 1.0000, which, according to Dr Kirwan, makes it 740 times lighter than an equal bulk of that liquid; its gravity compared to that of atmospherical air is as 1.103 to 1000. Mr Davy ascertained, that 100 cubic inches of that gas weigh 35.06 grains, which is more than what Lavoisier or Kirwan determined it to be; according to the calculation of these philosophers, 100 cubic inches weigh only 34 grains. Oxygen gas does not combine with water, unless the union has been affected by pressure, and then pure water absorbs only about half its own bulk; the solution does not possess any particular colour or smell, nor is the taste of it much altered from that of water in its simple state. At the same time, it is reported to possess all the usual properties of the gas in an uncombined state, when taken into the system.

Oxygen gas has a strong affinity for all the simple substances, with which it forms binary compounds, and it produces a variety of similar matters, by combining with the same body in different proportions; this degree of affinity is in general much increased by heat. But it is not simple bodies only with which it unites; it likewise enters into combination with many compound matters, whose properties it in general completely alters. In combustion it unites with sulphur, and forms sulphureous and sulphuric acid; with hydrogen gas it produces water, and perhaps muriatic acid; with carbon, carbonic acid gas is evolved; with different proportions of carbon and hydrogen gas, it forms an union, by which matters of very peculiar properties are generated, as alkohol, vinegar, ether. It is in consequence of its strong affinity for other matters, that it performs many essential purposes in the arts: it is particularly useful in this respect in the arts of bleaching and dyeing. Oxygen enters largely into the composition of vegetable matters, and it is sometimes found in animal substances; but in them it is always detected in very sparing proportion. According to an opinion which probably originated with Mayow, and which has been revived and supported with a variety of ingenious arguments by Girtaner, it is supposed to supply the principle of irritability in animals. The presence of oxygen gas is absolutely necessary in the process of germination, and indeed through every stage of vegetation. Animals can live longer in it than in the same quantity of any other respirable gas, except common air; but they also die in it, apparently from the excess of that principle so essential to the performance of the animal functions; it having been observed, that death ensues, though not suddenly, by breathing pure oxygen gas, its excessive stimulating effects producing a condition of the lungs inimical to life. All animals killed by respiring pure oxygen gas, are discovered to have had a highly inflamed state of the lungs; and in many instances its effects have gone so far as to bring on mortification, attended with many other symptoms of an increased circulation. Dr Beddoes found, that animals which had been immersed in a quantity of pure oxygen gas, and which were immediately afterwards drowned in water, could be always recovered, while the functions of similar animals, on whom the same experiment had been tried, without being previously exposed to oxygen gas, could not be restored.

When oxygen gas is inspired, it causes a very disagreeable sensation of heat in the chest; if respired for a few seconds, the pulsation of the arteries becomes more frequent and more full, the countenance turns florid, and the eyes inflamed; the heat of the body is then perceived to be augmented, and these appearances are accompanied with a distressing degree of anxiety and listlessness: these abate by ceasing to breathe the gas, when, generally, a perspiration breaks forth, which relieves the most urgent symptoms.

A taper, or any other inflammable body, continues to burn longer in oxygen gas than in the same quantity of atmospherical air, and the combustion is attended with a slight crackling noise; the flame is much more brilliant than in common air; it is extremely splendid and dazzling to the eyes; and the quantity of caloric given out is said to be much greater. These are the most remarkable properties of oxygen gas, and which sufficiently distinguish it from any other aërial fluid.

SECT. VI.

OF NITROGEN GAS.

THE general properties of nitrogen gas, as a constituent principle of the atmosphere, were most distinctly pointed out for the first time by Dr Rutherford, in 1772.

Nitrogen or azotic gas is never discovered naturally in an uncombined state; it is likewise contained most abundantly in the atmosphere; nevertheless it enters copiously into the composition of an innumerable variety of other bodies. The air that remains after oxidation, combustion, or any other eudiometrical experiment, is found to consist chiefly of this gas: after combustion, it is frequently mixed with a great portion of carbonic acid gas; this can be easily separated, by passing it through lime-water, or by exposing it to a quantity of pure potash. Combustion appears a very obvious, and by no means a difficult way of procuring a quantity of nitrogen gas; but Berthollet found, that it could be more conveniently obtained, and in a state of greater purity, by the following process. He directs a little bit of lean, muscular flesh, cut into small thin slices, to be put into a glass retort, with a quantity of nitric acid poured over it; the retort is then to be exposed to a heat equal to 100 of Fahrenheit, with its back immersed in a pneumatic trough, under a jar filled with water; in this manner any quantity of azotic gas may be collected. The water through which the gas passes in the receiver, prevents any mixture of acid; but if allowed to remain after being collected, a quantity of carbon is frequently precipitated, an impurity that is not easily avoided by this method. The best way of preventing it is to use a very diluted acid, and taking every precaution that the retort is not exposed to a stronger heat than what has been suggested by Berthollet. But to render it still freer of impurities, perhaps in every instance it should be passed through lime-water, to divest it of any portion of carbonic acid it may be accidentally mixed with.

Nitrogen gas procured in this way, is invisible, inodorous, and permanently elastic; its specific gravity is less than that of common air, being, according to Lavoisier, as 942.6 to 1000; but Mr Kirwan estimates it at somewhat more than this, being as .985 to 1000. Its deleterious effects on animals who respire it, as likewise its unfitness for supporting combustion, have been already pointed out. It is not, however, immediately unfriendly in vegetation, as plants are found to live and grow in it for some time: some vegetables, as mushrooms, ripe fruit, and flowers, are perceived to emit this gas when growing.

Nitrogen gas enters into combination with some of the simple substances, as hydrogen gas, with which it forms ammonia; it also dissolves small quantities of sulphur, carbon, and phosphorus, which it readily precipitates unchanged, especially when it meets with any substance with which it has a stronger affinity: its combinations with oxygen gas have been already mentioned. It would appear that water is capable of holding nitrogen gas in solution; but that the affinity of that liquid for this part of the atmosphere is not so strong as that which subsists between it and oxygen gas. Dr Priestley and Scheele also have shewn, that water is capable of holding common air in solution, and that it is always emitted from it in a purer state, consisting of a greater proportion of oxygen gas,—a fact which affords a certain degree of proof, that the atmosphere is partially resolved into its constituent gases during its solution in water. Nitrogen gas has however been frequently extricated during the melting of ice.

An opinion lately prevailed, that nitrogen gas is a compound body, an idea that was first suggested by some experiments of M. Achard: he found, that when water is made to pass through an earthen tube made red hot, a quantity of nitrogen gas always appears in the product of the experiment. Westrum imagined that he had detected this gas in making similar experiments with a metallic tube, and suggested an opinion, that water and caloric were the component parts of nitrogen gas. However, at a much earlier period Dr Priestley had perceived, that in performing similar experiments, an unusual quantity of common air was collected in the receiver, while the whole of the water employed in the experiment was nearly dissipated. By employing tubes of different materials, he perceived a variation in the result of the process: when he used a glass tube, no trace of azotic gas or common air could be discovered; and he found, that in every instance where earthen tubes were employed, their pores becoming enlarged by the heat, they had thereby afforded an outlet for the aqueous vapour, while at the same time common air was admitted, which had consequently undergone a partial decomposition. The subject was afterwards more minutely investigated by the Dutch chemists; and the result of their experiments fully prove the correctness of Dr Priestley's observation. At present, therefore, there does not exist even a probability in support of the supposed compound nature of nitrogen gas. It is nevertheless to be observed, that all the simple gases must, in a certain degree, be regarded as compounds, their bases being united with caloric, light, and perhaps electricity, as it is to their combination with these fluids that they owe their gaseous form. But although the present refinements of chemical science teach us to consider the simple gases in this way as compound bodies, it is merely by their effects that we are acquainted in any degree with the peculiarity of their bases.

SECT. VII.

OF CARBONIC ACID GAS.

This acid is always found in the state of gas, and the principles of which it is composed perhaps abound more copiously than any other in the universe. It is not yet fully ascertained, whether it forms a necessary principle of common air, or whether its presence in it should be considered as accidental, the consequence of various natural and artificial processes. It seems, however, that the former is the most correct opinion, it having been already observed, that this fluid is found in nearly an equal proportion in every situation, on the summit of the highest mountains, in the deepest pits, in the streets of crowded cities, and in the air over the cultivated plains.

Lavoisier was the first who scientifically examined the nature of this gas, after its discovery by the immortal Black : by his experiments, it is found, that 100 parts of it are composed of 72 parts oxygen gas, combined with 28 parts of charcoal or carbon: but since these experiments were performed, several important discoveries have been made respecting the nature of charcoal itself, and which give a very different result in the proportions of the principles of this gas. Lavoisier and the most celebrated chemists of his time, were accustomed to consider charcoal as a simple substance, indivisible into other principles; but it was owing to the very experiments of that celebrated philosopher on this subject, that an opinion was first suggested to others, that charcoal was not so simple in its nature as he had been led to conclude. He had perceived, that when the diamond is consumed by combustion, and the product of the process carefully collected, that this consists entirely of carbonic acid gas. Morveau confirmed the result afforded by Lavoisier's observations, in making similar experiments with some diamonds he was supplied with by the French government. He also discovered, that carbonic acid gas was produced by the combustion of diamond with nitrate of potash; and by experiments still more recently performed, both in France and in this country, the precise nature of diamond is now fully determined: Charcoal in its purest state being found to be the oxide of that gem, 100 parts of the matter of charcoal, consisting of 64 parts diamond united with about 36 of oxygen gas. Besides these proportions, Berthollet, Guyton, and others, have found, that carbon, even in its purest state, contains always a quantity of hydrogen gas; and in this way, it is ascertained, that pure carbon in combination with oxygen gas, in the composition of carbonic acid gas, forms about the proportion of one-fifth part of the compound, These experiments serve to shew, that the quantity of oxygen gas contained in a given portion of carbonic acid, exceeds considerably the calculation of the proportions of the constituent parts of this fluid as determined by Lavoisier. The opinion that diamond is inflammable, was originally suggested by Sir Isaac Newton; he had ascertained, that matters of an inflammable nature refract the rays of light more powerfully than other substances; and having perceived that the diamond possesses this property in the most perfect manner, he inferred from this observation, that it was either wholly inflammable itself, or contained a principle of the highest degree of inflammability. Carbonic acid gas is the heaviest of the different airs composing the atmosphere; 100 cubic inches weigh 46.7 grains; its specific gravity, according to Bergman, is to that of water as 0.0018 to 1.0000, varying somewhat according to the quantity of vapour it contains, and from which it is difficultly freed: this has been supposed by Berthollet to amount to 10 grains in 100 cubic inches of the gas.

Carbonic acid gas is evolved in the respiration and transpiration of animals; it is emitted by the leaves of plants during night, and it is the principal product in the burning of wood, sea-coal, and all kinds of fuel. It is likewise abundantly evolved in the course of fermentation and putrefaction, both of animal and vegetable matters; it can be readily procured by burning a piece of charcoal in oxygen gas; and it exists in a fixed state in limestone, barytes, strontian, and alkaline substances, with which it forms neutral compounds, and can be readily extricated from them by exposure to an high degree of heat, or by submitting them to the action of sulphuric acid: in this last instance, the gas can be received by means of a pneumatic apparatus; this is the most convenient method of procuring it. Carbonic acid gas is likewise perceived to be emitted through chasms formed in the earth, especially in countries subject to earthquakes and volcanic eruptions: the baneful vapour in the Grotto dei Cane, has been ascertained to consist entirely of this air. Carbonic acid gas proves fatal to animals exposed to its effects in respiration, though Chaptal observed, that it was absorbed by the larvæ of ants, and of some other insects, and that it had not a pernicious influence on spiders; in these instances, it seems to be decomposed. Burning matters are instantly extinguished when plunged in it. Plants appear to have a power of decomposing it; and by many accurate observers, vegetation is considered to be essentially promoted by its application. Carbon enters very abundantly into the composition of animal and vegetable matters. And although carbonic acid gas is followed by fatal effects when respired; nevertheless, when dissolved in water, or any other liquid, it has no such influence: on the contrary, it is frequently recommended by physicians for the cure of various disorders.

Carbonic acid gas is colourless, elastic, and, even though pure, it is the least transparent of any air; it produces a slightly pungent smell: in consequence of its great specific gravity, it may be poured out of one vessel into another like any liquid; it is soluble in water in considerable proportion, and the solution possesses a slight pungent acid taste, which turns the infusion of turnsole red. The strength of the solution is greatly increased by agitation and pressure; the weight of the solution is greater than that of pure water, being as 1.0015 to 1.000; it sparkles on being poured out, and is decomposed by boiling or by freezing; and the extrication of the carbonic acid is even occasioned by exposing the solution to the open air; this arises in consequence of the great attraction that subsists between the atmosphere and every artificial gas.

Carbonic acid gas is decomposed by phosphorus, and some of the most inflammable of the metals, as zinc, iron, and copper, when heated to a very high degree; the oxygen uniting with the inflammable substance, allows the charcoal to be precipitated. Besides the formation of neutral salts, with earths and alkalis, carbonic acid gas acts upon several of the metals, forming carbonates by combining with them.

It is carbonic acid gas that gives the sparkling appearance to wines, cyder, beer, &c. the loss of which completely destroys their agreeable flavour; but it can be readily restored by impregnating them with this gas, as it is evolved from limestone by the action of sulphuric acid, by means of Nooth's apparatus for such purposes.

Carbonic acid gas is found to exist in a pure state in several mineral waters, to which it communicates all its virtues; such are the waters of Spa, Pyrmont, &c.: in others it is united with matters generally of a saline nature, of which there are some in this country, as Moffat, Tunbridge, &c.

Carbonic acid gas frequently abounds partially in the atmosphere, commonly near to the earth's surface; this is on account of the great specific gravity of this fluid, and the innumerable sources from which it is continually extricated. In this way it is frequently met with in the vicinity of mineral springs, volcanoes, and in the bottom of mines, wells, cellars, and such places, where a free communication with the atmosphere is prevented; in these instances it is known by the name of choak damp.

As the respiration of this gas occasions instant death, and is a very general cause of asphyxia, melancholy consequences frequently occur from being exposed to its effects; every precaution should therefore be taken against its deleterious powers, before descending into situations where a free access of the atmosphere has been precluded.

A burning candle should be therefore let down to the bottom of such places before workmen enter; if the light be then extinguished, the respiration of the air in them would be probably fatal. It therefore becomes necessary to use every means for establishing the circulation of the atmosphere. This is done by leaving open the entrance to the pit or mine; the atmosphere will then gradually mix with, and dissipate the noxious gas. Besides this general direction, when carbonic acid abounds in the bottom of a mine, the circulation of the atmosphere may commonly be established through it, either by forming a new shaft, or by re-opening one, if such has been originally formed; this intention is likewise promoted, by kindling fires at the mouth of the pit. But in circumstances where a counter opening cannot be formed, as in wells, cellars, &c. they may be freed of this gas by being inundated with pure water, and means must be taken to cause its agitation, in order to increase its solvent powers. Frequently a considerable quantity of water is found at the bottom of such situations; but in these instances, disturbing it may be attended with great risk, as this frequently causes the extrication of a gas even more deleterious than carbonic acid itself; in that case, a stream of pure water should be turned, if possible, into the place where the gas abounds. In such circumstances, a quantity of fresh burnt lime thrown into the pit or mine, produces a double effect; the heat extricated causing a rarefaction of the air, which therefore assists in expelling the carbonic acid gas; at the same time, the lime in slaking will absorb a quantity of the gas itself. When the pit is deep and narrow, this gas, from its great specific gravity, may be pumped out, by fixing closely the valvular orifice of a pair of large bellows upon the top of a long wooden tube, having holes drilled in its under extremity: the same operation is in this manner to be performed as in pumping water out of mines.

On account of the copious production of carbonic acid gas during the performance of the animal functions, bed-chambers, dwelling-houses in general, stables, &c. ought to be so kept, that a free current of air may be established through them. Fires are useful in bed-rooms, by carrying off the air that has been already respired, and by affording a free admission to the external atmosphere; but particular attention must be bestowed in ascertaining thoroughly the draught towards the chimney; as in instances where the fire-place is too narrow or too wide, a fire would have a very opposite effect, and in place of removing the air deteriorated by respiration, it will add to all the deleterious effects of carbonic acid, by the formation of a greater quantity of that gas, in the combustion of the fuel. The accumulation of carbonic acid gas in bed-rooms, sitting-rooms, and crowded places of assembly, is often productive of the most alarming complaints; this may be regarded as the general cause of many of the nervous disorders with which women and delicate people are so liable to be affected. It is often perceived, that tremors, the most distressing symptoms of hysteria, nervous headach, and dyspepsia, together with a sallow complexion, have originated from want of a free admission of fresh air into bed-rooms, and places where the air is not renewed so often as necessary. In such apartments, growing vegetables, during sunshine, are supposed to be of the highest utility in correcting the atmosphere, by decomposing the carbonic acid, and by producing a consequent emission of oxygen gas; but they must be carefully removed before sunset: those plants which are not in flower or bearing fruit, are best fitted for this purpose. The burning of pastils and other perfumes, in order to purify the air of apartments, must have always an opposite tendency, as they load the air with an additional quantity of carbonic acid gas, disguised by their peculiar aroma. Carbonic acid gas is evolved in all natural processes, probably in a quantity nearly equal at all seasons of the year. Dr Guthrie found, that the moisture frozen in the insides of the windows of the houses of Petersburgh, during winter, is highly volatile; and on being thawed, it gives out a gas equally pernicious, and in other respects possessing similar properties to those of carbonic acid gas. In a matter of so much importance, an attention to keep a free current of air in places where people pass the greatest part of their time, cannot be too earnestly inculcated. In every situation, the air of close or crowded apartments is almost always more insalubrious than what can be admitted from the most frequented street: this circumstance should never be a mean of preventing its admission, though it is evident the purer and more free the air that comes in, so much more beneficial will be its effects.

The means that are recommended for the recovery of people from a state of insensibility, occasioned by respiring carbonic acid gas, are similar to the methods employed in every other case of suffocation, from whatever cause it may have originated, as submersion, lightning, hanging, &c. In slighter cases, the dashing of cold water upon the body suddenly, the application of stimulants to the nose and temples, or placing hot irons near to the soles of the feet, has had the effect of rousing the patient. In severer cases, frictions, warm bathing, rubefacients, sternutatories, and the electric shock, have all been employed; but no method has been followed with so much success, as by artificially inflating the lungs. This may be done, by blowing into the patient's mouth, or one of his nostrils, by means of a pair of common bellows; but in performing this operation, it is necessary to grasp the upper part of the throat in such a way as that the air may be prevented from descending by the œsophagus. The Humane Society has recommended a double bellows, by which this intention is better performed; and when these are filled with oxygen gas instead of common air, the effect will be so much greater. Oxygen gas can be at any time readily procured from the nitrate of potash, by the method already mentioned under the article oxygen gas. In desperate cases of asphyxia, the operation of bronchotomy has been advised, for the more certain admission of air, for the purpose of inflating the lungs: when judged necessary, the operation should be instantly performed; it is not dangerous in its consequences; and the beneficial effects that may result from it must be more certain, the sooner it is had recourse to.

SECT. VIII.

OF THE COMBINATION OF THE CONSTITUENT GASES IN THE FORMATION OF THE ATMOSPHERE.

A CONSIDERABLE difference of opinion has prevailed of late years respecting the manner in which the constituent principles of the atmosphere exist in the composition of this fluid. Some chemists have supposed, that they are united merely in the form of mechanical mixture; while other philosophers bring forward the most conclusive reasoning to show, that they exist in it in a state of chemical combination.

It has been already mentioned, that Lavoisier mixed together a quantity of oxygen and nitrogen gases, in the same proportions he had detected them in the formation of the atmosphere; and this celebrated philosopher imagined this mixture exactly corresponded in its qualities to those of atmospherical air. But it has been perceived, on minutely examining this experiment, that there is a very considerable difference of the properties of an equal measure of common air and of the mixture of these gases. It has been found, that a greater proportion of oxygen can be extracted, by means of an eudiometer, from this sort of mixture, than from an equal measure of common air. Combustible matters burn in it with a brighter flame, and for a longer time; and animals are found to live longer in the artificial mixture. We have already had occasion to mention, that the proportions of the component parts of the atmosphere have been found nearly the same in every situation, and in every variety of climate. Ingenhousz has, however, ascertained, that the proportion of oxygen gas is greater in a given quantity of air over the ocean at all times, and likewise in that over land in cold weather. This deviation appears to be easily accounted for, and is seemingly a consequence of the purer state of the atmosphere over water, which has the power of dissolving many accidental impurities exhaled from the soil, with which the air is occasionally impregnated. Besides, in the former situation, it cannot be loaded with the variety of extraneous exhalations which is frequently found contained in the atmosphere over land. In winter, the atmosphere is much freer of impurities every where; then, every exhalation being repressed, and condensed during the prevalence of cold weather, of course there will be greater proportions both of oxygen and nitrogen gases, in a given quantity of the atmosphere, than in an equal portion of it taken from over land or during summer, when it is more liable to be affected with impurities. Nevertheless, De Marti has discovered the constituent principles of the atmosphere existing in the same proportions in every condition and situation, whether as to temperature, winds, density, humidity, or season of the year, in crowded streets, or in the fields at a distance from all contaminating substances.

But were the constituent principles of the atmosphere to exist in this composition merely in the form of mechanical mixture, their specific gravities differ so widely, and the difference of their proportions to each other is so great, that the higher regions of the atmosphere must have had a superabundance of nitrogen gas; while the oxygen gas would be in like manner found to exceed its natural proportion in the lower strata: and in these circumstances, the carbonic acid would have been only discovered close to the earth's surface. Neither does it appear, how the natural elasticity of these gases should produce an uniform mixture of them, in opposition to the difference of their specific gravities, and to the remarkable disproportion of their quantities in the composition of the atmosphere.

It seems likewise extremely probable, that the permanent quantity of the whole atmosphere depends in a very great degree upon the affinity existing between the matters composing it; for, were the mass of air merely a mixture of the nitrogen and oxygen gases, its absolute quantity would not only be more subject to variation, but its qualities must have occasionally changed, according to the season of the year; and it would have been found, most probably, differing in this respect in every climate, and the appearance of meteors very different from such as are now commonly met with, must have been the consequence of the constitution of its principles in that manner. The celebrated Berthollet, however, considers the existence of the oxygen and nitrogen gases in the composition of the atmosphere as in that of a state of mixture. This opinion he supposes receives confirmation, by finding, that the specific gravity of the atmosphere amounts nearly to that which corresponds to the mean of both its constituent fluids; and he likewise imagines, that the uniform proportions of the oxygen and nitrogen gases found in every situation, is brought about by the continual agitations of the atmosphere itself. But even admitting the accuracy of this explanation, does it not follow, that the diffusion of every exhalation from the earth's surface should take place from the operation of this cause, and consequently, that foreign matters occasionally existing in the atmosphere should be found dispersed equally throughout every portion of it? The opinion of the atmosphere being formed in consequence of a chemical combination of certain gases, has been perhaps opposed in the most ingenious manner by Mr Dalton. The opinion he entertains respecting the nature of the atmosphere, was formerly mentioned, when treating of evaporation; but which we shall now attend to more particularly. This philosopher supposes, that the uniform mixture of the nitrogen and oxygen gases in the formation of the atmosphere, is in consequence of the following general law. The particles of a heterogeneous fluid, such as he imagines the atmosphere to be, neither attract nor repel the particles of each other; or that the existence of any gas acts the same as a vacuum to every other gas, opposing no sort of resistance to its ascent and motion; this being contrary to what he supposes takes place between the particles of an homogeneous fluid, which are known to repel each other with a force decreasing directly as the distance of their centres from each other. But, for the reasons we have already stated, we are still inclined to doubt of the validity of this explanation. The uniform proportion of the principles of the atmosphere in every portion of it; their existence in this manner in every climate and season, together with the difference between an equal portion of the atmosphere and of an artificial mixture of its constituent gases, show clearly the inefficacy of this theory, in accounting for the constitution of its principles. This seems likewise to be rendered still more evident, by finding, that the addition of artificial gases, and exhalations of every sort, always arrange themselves in the atmosphere according to their specific gravities and affinities to that fluid; or till, in consequence of the pressure of the atmosphere, they are diffused through it. Were this not the case, we should never find carbonic acid gas in accumulated quantities, where the air has access to it; as it must have ascended, and diffused itself through the atmosphere, in consequence of its properties as an elastic; and it was evidently in consequence of a difference of specific gravity from that of the gases constituting common air, that Dr Higgins found this fluid most abundant in the under part of the vessels in which he had conducted some experiments on respiration. In like manner Fontana found, that hydrogen gas, when mixed in a vessel containing atmospheric air, or a quantity of any of the artificial gases, so far from diffusing itself equally throughout, ascended always in greater proportion to the top. That the gases composing atmospherical air are combined in the constitution of that fluid, in consequence of the affinity subsisting between them, is to be inferred, by finding that the other substances formed by different proportions of them are not generated by being merely mixed together in their respective proportions; an high temperature, perhaps pressure, and a minute apposition of these principles, being found necessary in every instance to produce that effect. It is likewise to be observed, that were the atmosphere a composition formed by the mechanical mixture of certain gases and aqueous vapour, according to Mr Dalton's opinion, we are still unable, by this theory, to comprehend why these gases alone should be always found in certain proportions in the composition of this fluid, or why, on the supposition that the existence of any gas does not affect the elasticity of any other with which it happens to be mixed, we should perceive a difference in the proportion and celerity of the evaporation of water at different heights above the earth's surface, and these always corresponding to the diminished pressure of the circumambient air.

But Mr Davy has shewn, by experiment, in his Researches, and Mr Gough likewise has demonstrated, that a mixture of the constituent gases of the atmosphere, in the proportions they exist in the formation of this fluid, possess a greater specific gravity than an equal volume of atmospherical air. Mr Gough, in opposition to the peculiar theory of Mr Dalton, likewise considers the homogeneous nature, or intimate combination of the constituent gases of the atmosphere, to be evinced by its being a diaphanous fluid, which he thinks could not have been the case, were the atmosphere to consist of a mass of aërial fluids merely in a state of mixture, and pervading the pores of each other. The multiplicity of the refractions of the solar rays must, in this constitution of the atmosphere, have diminished their illuminating powers to such a degree, as to render them unequal to lighten this globe; and at the utmost, a kind of twilight would have then only prevailed. The same ingenious philosopher brings forward another forcible argument against Mr Dalton's opinion; he observes, that in consequence of the difference of density between the oxygen and nitrogen gases, were they in the composition of the atmosphere to exist simply in the form of mixture, every sudden report must in that case have seemed double, at a certain distance from the origin of the sound; as every report would arrive more expeditiously at the organ of hearing, through the medium of the nitrogen gas, than through the medium of the oxygen gas. For a more full account of the arguments adduced both by Mr Gough and Mr Dalton, respecting this question, we refer to the 8th and 9th volumes of Nicholson's Journal. The ingenious Mr Murray has entered into a discussion of the merits of Mr Dalton's opinion on this subject, which, by a series of the most correct reasoning, he demonstrates to be incompatible with the appearances which take place; and the arguments and facts he adduces in support of the opposite opinion, enable him to form the following conclusion: "It has appeared as a fair deduction from the phenomena of chemical affinity, that an attraction may be exerted between two substances, though it may not be sufficient to overcome opposing forces, so as to unite them intimately: and the farther assumption will not surely be regarded as an improbable one, that this attraction may counteract the difference in the specific gravities of these substances, especially where it is not considerable, and prevent them from separating from each other."—See System of Chemistry, vol. ii. Note E. This doctrine, when applied to the subject under discussion, must make it appear sufficiently probable, that the attraction between oxygen and nitrogen gases may, at common temperatures, be sufficient to counteract the slight difference in their specific gravities, and prevent them separating from each other.

While Mr Davy was engaged in prosecuting some experiments respecting the nature of nitrous oxide gas, he perceived that a gas was occasionally extricated, possessing all the properties of common air: in no compound of oxygen and nitrogen gas, has their chemical union been called in question, except in atmospheric air; however, it may be reasonably supposed, that the same affinity existing in one case, will continue to effect similar changes upon the same matters in every other circumstance, only differing in degree. This is experienced to take place in the different combinations formed by any two substances, among the various objects of chemical investigation. There are many simple bases, which combine with various proportions of oxygen gas, and where the combination is perhaps not equally intimate in every instance. In this manner, we possess a variety of oxides of the same metal, and which only differ in the proportion of oxygen they contain: and in this way, sulphuric and sulphureous acids are found to be generated.

It is found, that by mixing a quantity of oxygen and nitrogen gases in the proportions they are known to exist in the atmosphere, they do not enter into a chemical union: something besides their affinity for each other, and connected with the composition of the atmosphere itself, is perhaps the mean of causing these fluids to combine in the formation of the circumambient air. It seems probable, that the electric fluid acts a principal part in bringing about this union; but what its precise effects are in this respect, still remain confined within the bounds of conjecture. But, whatever this connecting medium may be, we have many reasons to rest satisfied, that the beneficent Author of nature has not exposed the formation of the atmosphere to fortuitous accident; which, in the accuracy of its composition, and in the permanency of its entire quantity, is so essentially necessary in the general economy of the universe.

Having given a general account of the physical and chemical properties of the atmosphere, the effects of this medium, or its influence on animals and plants, come next to be considered. But in treating of the subjects which follow, it will be attended with some advantages, to communicate the necessary observations in an order somewhat reverse to that which was followed in the preceding arrangement. We shall therefore begin with the powers of the atmosphere, as a chemical fluid, on these bodies; and the succeeding chapters will be occupied with an investigation of the influence of its physical qualities, on the same class of beings.

PART III.

CHAP. I.

OF THE INFLUENCE OF THE ATMOSPHERE AS A CHEMICAL FLUID ON ANIMALS AND PLANTS.

SECT. I.

OF RESPIRATION.

THE function of respiration may be considered as common to every class of animals, though the organs by which it is performed are not alike in all; the purposes which are effected by it appear, however, to be similar, so far as the process has been investigated by experiment. Some animals have the faculty of inhaling the atmosphere by lungs, while others are endowed with organs seemingly very different, but whose operations are not less intimately connected with their existence. It has been ascertained, that the atmosphere suffers a similar alteration by the transpiration of an insect, as occurs when it is respired by man, or any other animal inhaling it by lungs. Although no animal can live without a free communication with the atmosphere, the necessity of breathing is not equally frequent in every class. Man respires on an average at the rate of 20 times in a minute: other warm-blooded animals breathe more seldom; while those of the amphibious class can suspend this process, and not perform it oftener in the period of 24 hours. In this way, they can resist for a short time the noxious effects of several gases, which prove suddenly fatal to the former class; nevertheless, all animals die when the air around them is not renewed, though this event does not occur within a definite space of time alike to every one. Thus, the smaller kinds of quadrupeds, and birds, almost instantly die when confined within an exhausted receiver.

Worms, snails, and insects in general, when confined in a vacuum, or in any of the irrespirable gases, or by having the openings of their spiricula thereby covered over with oil or mucilage, perish in a similar manner. Fishes do not live in distilled water, and they very speedily die when the communication between the atmosphere and the water in which they are confined is prevented, by interposing a thin stratum of oil on its surface. The cause of the uniformity of this event occurring to every kind of animal, when precluded from respiring the atmosphere, will be most distinctly illustrated, by attending to the function of respiration in man and warm-blooded animals; the observations that have been made on this process, being, but with few exceptions, the result of experiments made on this last class of beings.

Respiration implies the actions of inspiration and of expiration. The former is performed by the co-operation of a great variety of muscles, whereby the glottis is opened, and at the same time the thorax becomes elongated, and its capacity enlarged. In this state, the atmosphere, by its gravity, necessarily rushes into the lungs, which are thereby inflated. Expiration is meant to express the expulsion of the inspired air from the cavity of the lungs; this is not effected merely in consequence of the muscles having ceased to act, whereby the former motion was accomplished; but it is performed by the united action of certain other muscles, which have a power to elevate the ribs, by which the thorax is compressed, the space occupied by the lungs, when inflated, being diminished; therefore the whole or the greatest part of their contents must be expelled. Although these motions are not occasioned by the action of muscles immediately connected with the lungs themselves, and although muscular fibres have not been commonly detected in the structure of that organ, it seems probable, from the experiments of M. Bremond, related in the Mémoires de l'Accademie des Sciences for 1739, that they are not entirely passive in respiration, but have even the power of dilating and contracting themselves, independently of, but synchronous with, the motions performed by the ribs and sternum. This opinion seems to receive confirmation from observing what takes place in spasmodic asthma, and other diseases where the lungs are chiefly afflicted: it may therefore be considered, that the lungs, by a peculiar action in themselves, do perform a very important office in the functions of inspiration and expiration. Respiration is under the influence of the will, to a certain degree, though it is evident that this function must have commenced as an involuntary motion.

In prosecuting the following inquiry, the explanation will be rendered more distinct, by first endeavouring to determine the changes which the air undergoes by being respired; in the second place, it is necessary to attempt to discover by what means these changes are effected; and next, to point out the uses which the function of respiration serves in the animal economy. Having previously made ourselves acquainted with the principles which compose the atmosphere, and the properties of the gases forming that medium, whatever changes it may undergo, will be therefore more readily comprehended. It has been already mentioned, that by confining an animal in a certain portion of air, a complete alteration of its properties ensues, and that even a certain portion of it disappears during the experiment. It is ascertained that air which has been respired is no longer fit for a repetition of this process, and that matters in a state of combustion are immediately extinguished when immersed in it; and it is found not to answer any purposes which the atmosphere performs in its entire state, except those depending on its mechanical properties. This experiment clearly shews, that, as in combustion, it is the oxygen gas of the atmosphere which principally disappears during respiration, an opinion which is confirmed by finding, that the quantity of air amissing by the performance of this process, nearly corresponds to the proportion of oxygen gas originally contained in the air respired; and that air, deprived of oxygen gas by calcination, combustion, or any analogous process, does not answer for the performance of this function; nevertheless, though it has been very generally supposed, that the loss of air in respiration is entirely owing to the absorption of oxygen gas, Mr Davy has, however demonstrated, by more recent experiments, that a portion of the nitrogen gas of the atmosphere likewise disappears in the exercise of this function.

At a very early period in the progress of investigating this subject, Dr Black was accustomed to shew, that when air is expired through a bent tube, containing a quantity of lime-water, the solution becomes instantly turbid: this is occasioned by a portion of carbonic acid gas being imparted to the air inspired, which, passing through the solution, saturates the lime, and thereby renders it insoluble in water. The proof of the correctness of this theory is easily demonstrated, by previously inhaling the atmosphere through the solution, which in that case remains unaltered by it. Besides those changes in the constitution of the air by respiration, a quantity of aqueous vapour is at the same time emitted from the lungs; and it is rendered evident, that the temperature of the air expired is considerably augmented by being submitted to the action of this organ. It has been likewise ascertained, that air, in a positive state of electricity, is rendered negative by the same operation; Mr Read (in the Phil. Trans. for 1794, 2d part, p. 270.), having found, that air impregnated by respiration and vegetable putrefaction, always shewed a negative state of electricity, when the surrounding atmosphere was charged positively. In this way it is demonstrated, that a portion of the atmosphere, in consequence of being respired, uniformly contains an additional quantity of carbonic acid gas and of watery vapour; nearly the whole of its oxygen gas, with a small proportion of its azotic gas, having disappeared; the temperature of the mass being considerably augmented, with a corresponding diminution in its natural state of electricity.

It is a matter of the greatest importance in the explanation of the function of respiration, to determine the quantities of carbonic acid gas and of vapour which are communicated to the air inspired; as also to define the proportion of oxygen and nitrogen gases, which disappear in consequence of that process. These changes very probably depend on the frequency with which that function is performed, and the quantity of air that is submitted at a time to the action of the lungs: the number of respirations are not the same in every person, nor in the same person at different periods of life; and the quantity of air inhaled must depend greatly on the capacity of the cavity of the lungs themselves, according as they are sound, or tending to disease: the power of habit must have likewise a considerable effect, both in varying the frequency of respiration, and also in regulating the quantity of air inspired. It will be therefore readily comprehended of what importance a minute attention to these circumstances bear, in performing experiments to elucidate this function.

Mr Davy performs respiration about twenty-seven times in a minute; but Dr Menzies found, that a man on whose respiration he conducted most of his experiments, did not respire more that half as often in the same space of time, being only fourteen times in a minute: and the celebrated Fontana makes it from sixteen to eighteen times in the same period. However, by the calculation of Dr Hales, twenty inspirations in the course of a minute is the general medium to be assumed for the frequency of this motion.

After every expiration, and even when the motion is performed with force, and care taken to expel as much of the air as possible, a considerable quantity of it is still found to remain within the cavity of the lungs. Dr Goodwin makes an estimate from experiments made on his own respiration; that after an easy expiration, the quantity of air remaining in his lungs amounts to about 109 cubic inches; but Mr Davy calculates, that only 41 cubic inches remain in his chest after a forcible expiration; and when that motion has been easy, it still contains 118. He has likewise ascertained, that his thorax contains 135 cubic inches of air by a natural inspiration; but when the motion has been voluntary, the quantity which his lungs are capable of holding amounts to 254 cubic inches. He emitted by a forced expiration, after a full inspiration, 190 cubic inches of air; but after a natural inspiration, the quantity expired amounted only to 78½. But this calculation is much higher than what Dr Menzies estimates it; he thinks the medium quantity of air which a man inspires is about 44 cubic inches,—a calculation which agrees tolerably well with that of Jurin, who determines the quantity of air which an ordinary sized man inspires to be 40 cubic inches; and by the fullest inspiration, he found that his lungs were capable of receiving 220 cubic inches; which, on calculating the difference between French and English measure, does not differ very widely from the above-mentioned statement of Mr Davy. Nevertheless, it appears from some experiments of Dr Goodwin, that the quantity of air inspired rarely amounts to so much; in one set of experiments, it seems even to have been only 3 cubic inches on an average, at an easy inspiration.

It has however been generally estimated, that about 40 cubic inches of air is the medium quantity received into the lungs by a natural inspiration.

Dr Goodwin found, by examining 12 cubic inches of atmospheric air which he had respired, that 1.56 part of the whole had disappeared; but, according to Lavoisier's experiments, it would seem, that about $\frac{1}{20}$ part of the volume of the air becomes amissing, in consequence of the same experiment. Dr Menzies has confirmed the accuracy of this statement; and also, the more recent and equally correct experiments of Mr Davy shew, that the volume of the mass of air which is extracted by this function, amounts to $\frac{1}{19}$ of the whole: but the discrepancy of these calculations probably arises from the operation of some of the causes stated above. Several experiments to determine this question were originally conducted by Lavoisier himself, and afterwards he was assisted in his labours by Seguin; from the result of these, it appears, that the quantity of oxygen gas absorbed from the atmosphere in the course of twenty-four hours by respiration, amounts to about 33 ounces, and that it bears a proportion to the quantity of carbonic acid gas evolved in the same period, as 33 of the former to 37 of the latter.

De la Metherie has however calculated, that 360 grains of oxygen gas disappear in the course of one hour by respiration,—a proportion that does not greatly exceed one-half the above calculation. But Dr Menzies found by his experiments, that the proportion of oxygen gas absorbed in this process, exceeded even the quantity determined by the experiments of Lavoisier; he discovered, that 2.1885 cubic inches of oxygen gas were absorbed at each respiration: this proportion, in the course of twenty-four hours, amounts to about 42 ounces weight. However, Mr Davy's experiments seem to give confirmation to the accuracy of Lavoisier's statement; he found, that the quantity of air which disappears by respiration, is somewhat more than 38 ounces in the twenty-four hours; of which he supposes, 33.54 ounces consist of oxygen gas, the remainder of nitrogen gas. His experiments, as well as those of Lavoisier, were conducted with much ingenuity, and every precaution was taken to insure accuracy; we may therefore trust to the correctness of the result. But if we take into consideration the greater frequency of Mr Davy's respiration, (being about one-third oftener than the general medium determined by Dr Hales), the quantity of oxygen gas that is absorbed in this process, being so much greater, by making a proportional deduction, the medium will approach nearer to the quantity estimated by De la Metherie; though perhaps his calculation is somewhat below the common mean.

At a very early period of pneumatic chemistry, the probability, that a part of the azotic gas of the atmosphere is likewise absorbed in respiration, was shewn by some experiments of Dr Priestley; though, from the manner in which these experiments are related, it is difficult to comprehend either the exact proportions of the gases which disappear, or the real views the author entertained of the result.

He respired 100 measures of air, till it was reduced almost to one-half; the remaining quantity being washed with water, and afterwards analyzed by means of nitrous gas, it proved decidedly, that a portion of the nitrogen part of the atmosphere had disappeared, and that too in a considerable quantity; in one instance it would seem that 14 ounces of that gas had been absorbed from 100 ounces measure of common air. But in some later experiments, Dr Priestley seems inclined to impute the deficiency of this gas by respiration, "to the greater proportion of it in the lungs after that process than before:" though at one time, he says, he had repeated the experiment so often, and always with a similar result, that, in his own words, "I am confident, I cannot be mistaken, in this (his former) conclusion." By the latter experiment, he however sets aside every idea respecting the absorption of nitrogen gas in respiration, which the result of his former trials had so plainly inferred.

Lavoisier, who, by his ingenuity, industry, and accuracy, has done more than perhaps any other person in illustrating this abstruse branch of science, seems also decidedly of Priestley's latter opinion. He says, "Nous nous sommes assurées, que réellement il n'y a degagement ni absorption de gas azote pendant la respiration;" and he expresses himself in another part of his writings still more strongly: "Que l'air vital est la seule qui soit essentielle au maintien de la respiration; la moffete n'y concourt en rien; *si bien qu'on pourroit même substituer à la moffete atmospherique un autre fluid mephitique*, pourvu que ce fluid n'est point de qualité irritante et deleterré, pourvu que'lle ne fut mêlé dans l'air vital que dans la proportion de soixante douze parties sur cent, et resulteroit de cette combinaison un fluid également salubre, également respirable que l'air de l'atmosphere."

This idea seems to have presented itself in consequence of the preconceived opinion which this ingenious man had formed of the combination of the oxygen and azotic gases in the formation of atmospheric air. This opinion, however, was completely refuted by more recent experiments, conducted by himself and Seguin; when it was found, that even a mixture containing 0.15 of carbonic acid, 0.40 of azotic, and 0.45 of oxygen gas, destroyed animals confined in it. In p. 334 of the Minutes of a Society for Philosophical Experiments, there is the account of some experiments on this question by Dr Powel, which most decidedly refute the view of it assumed by Lavoisier. A full-grown bird was immersed in a mixture of three-eighths of oxygenous, and five-eighths of carbonic acid gases; and he survived the immersion but a few seconds: and when the mixture consisted of oxygen and hydro-carbonate gases, the same event ensued.

But, within these few years, Mr Davy has completely established the correctness of Dr Priestley's original observation. By the result of a series of well-conducted experiments on respiration, it appears, that a portion of the azotic gas is absorbed, as well as the oxygen gas of the atmosphere, during the discharge of this function; and that the quantities of those gases which had disappeared in this way during the space of a minute, amounted to 31.6 cubic inches of oxygen gas and 5.2 inches of nitrogen gas, being about a sixth part of the former. The result of these experiments he likewise confirmed, by subjecting small animals to respire certain portions of atmospheric air and oxygen gas. Though the proportions of the constituent principles of the atmosphere which become amissing during respiration cannot be determined with precision, as the quantity inspired probably varies in each individual, and the difficulty of completely voiding the lungs of a portion of the air previously inspired, independently of the anomalies which must arise from the circumstances already mentioned; nevertheless, it is evident, that a portion both of the oxygen and azotic gases of the air are extracted by this process, though in very different proportions. This is also the result afforded by several experiments on this subject by Spallanzani; who found, that snails and other insects effect similar changes on the composition of the atmosphere as the warm-blooded animals; and that the greatest part of the oxygen and a part of the nitrogen gas disappears, from a given quantity of air. By experiments on respiration, performed by Professor Pfaff of Kiel, it is likewise demonstrated, that a portion of the nitrogen gas of the atmosphere is extracted from the air by this function; and, in every particular, his experiments confirm the result afforded by those of Davy, in his attempts to elucidate this process.—See Nicholson's Journal, NO. 48.

That a very considerable portion of carbonic acid gas is generated during respiration, is rendered evident in the manner already mentioned; but the quantity of this fluid evolved in a given time, and the proportion it bears to the quantities of oxygen and nitrogen gases which are absorbed by this function, has not yet been determined accurately; and probably similar causes to those occasioning variations in the former case, will give similar differences in the result afforded by investigations of this part of the question. The quantity of carbonic acid gas which is generated has been supposed to depend on the proportion of oxygen gas that is absorbed in this process. These calculations have been minutely attended to by Lavoisier, Crawford, and others. Dr Priestley respired 100 measures of air till he perceived that 12 parts of oxygen gas had disappeared, and that 4.4 parts of carbonic acid were produced. In this experiment, 8.7 of oxygen gas is unaccounted for, as but 3.3 parts of the whole that was absorbed had combined in the formation of carbonic acid. He conducted many similar experiments on the same subject; and though the results afforded by them, in regard to the proportion of oxygen gas absorbed to that of the carbonic acid gas produced, were various, still, in every instance, the quantity of the former that had disappeared was considerably more than what is necessary for the composition of the carbonic acid gas that is extricated by this function. By some experiments of Lavoisier and Seguin, the quantity of carbonic acid emitted during respiration amounts to about 16 ounces in the course of twenty-four hours; and we have seen, that the quantity of oxygen gas imbibed during the same time amounts to 33 ounces. In the account of similar experiments by the same philosophers, the absorption of oxygen gas is said to be, in the proportion to the emission of carbonic acid, as 33 to 37. It is, however, difficult to reconcile the discordance of these experiments, or to explain from what cause an error has arisen. Dr Goodwin respired a quantity of the atmosphere, with the proportion of whose principles he had previously made himself acquainted, which measured 12 cubic inches, or 100 parts: after the experiment, it was found to contain 15, and in another instance, 13 parts of carbonic acid; the proportion of oxygen gas that had disappeared being barely sufficient for its formation. In Mr Davy's experiments on this subject, there is some small difference, evidently arising from the extreme delicacy of the inquiry: nevertheless, it appears, that the quantity of oxygen gas absorbed from the air in respiration, is in every instance more than the proportion of that fluid which enters into the composition of the carbonic acid gas which is evolved. After a complete expiration, temperature 63°, he breathed 161 cubic inches of air for near a minute, making in the time 19 deep inspirations; after expiration, the air was reduced to nearly 52 cubic inches, of which there were 17.4 of carbonic acid, while 19.4 of oxygen gas had disappeared. In experiments to ascertain the quantity of carbonic acid evolved in respiration, it is necessary to keep in mind the observations of M. Jurine: he found, that a quantity of azote is frequently emitted with the air expired; this cause of variation most probably happens in consequence of the air remaining in the lungs after each expiration.

From the whole of these observations it will be perceived, that the oxygen gas absorbed rarely corresponds to the quantity of that gas in the composition of the carbonic acid gas evolved in respiration: sometimes it exceeds considerably the necessary measure; in other instances the proportion is not sufficient to form with carbon the quantity of this fluid which is extricated. It is therefore probable, that the formation of this air does not immediately depend on the absorption of oxygen gas, during the performance of this function,—an opinion which is rendered still more probable, from other experiments by Mr Davy. He perceived, in his researches on this subject, that carbonic acid gas was produced during the respiration of hydrogen gas, and by respiring 102 cubic inches of oxygen gas, during seven deep inspirations, of which 247 cubic inches had disappeared, while only 5.9 of carbonic acid gas was given out; in another experiment, 11.4 of oxygen gas had been consumed, while only 3.8 of carbonic acid gas was produced, and that equal portions of carbonic acid were produced, by respiring hydrogen gas and nitrous oxide, for the same length of time. Spallanzani, in his Memoirs on Respiration, p. 351, gives us the result of similar experiments upon snails, in the following words: "I shall only conclude from these experiments, that it is clearly proved, that the carbonic acid gas produced by the living and dead snails in common air, results not from atmospheric oxygen, since an equal, and even a greater quantity of it, was obtained in azotic and hydrogen gases." The experiments themselves appear to be so accurate, that there cannot exist any hesitation in acceding to his inference. Chaptal says it has been observed, that frugivorous animals vitiate the air less than carnivorous animals. There is likewise some reason to believe, that the changes which the atmosphere undergoes by being respired, either as to the quantities of its component gases absorbed, or in the proportion of carbonic acid evolved, are especially subject to variations from the functions of digestion and assimilation, and must likewise vary considerably in different individuals, according to constitution, habit, and state of health. The following experiments render this opinion probable. Spallanzani found, that though snails, after a full meal, consumed an equal quantity of oxygen gas, still the quantity of carbonic acid evolved was then much greater, and more nitrogen gas was absorbed than when the animals are starved. Lavoisier and Seguin, in their experiments on respiration, have ascertained, that the same thing takes place in man in an equal temperature: a person during digestion absorbed fully one-third more of oxygen than with an empty stomach, it being 1900 cubic inches to 1210 in the former state; and during violent exercise, the quantity has amounted to 4600 inches in an hour. This is an experiment, that by being confirmed by similar observations on other animals, might be of the greatest practical utility. Upon the whole, taking the calculations in a general way, it may be supposed, that from 30 to 38 cubic inches of oxygen are consumed by an adult in a minute, and that the quantity of carbonic acid evolved in the same time amounts from 20 to 26 inches.

It is extremely difficult even to approximate the truth by any experiments, in order to ascertain the quantity of watery vapour evolved with the expired air. The first who attempted an explanation of this question was Dr Hales: he estimates its amount at 20¼ ounces in 24 hours. But Lavoisier makes the calculation much higher; and as the method he took to determine the matter was susceptible of more accuracy than the contrivance of Dr Hales, the result must therefore be relied upon with more confidence; he found it to amount to 28.55 ounces. But any experiment on this subject must be so conducted, as to include the quantity of vapour contained in the air respired, previous to being submitted to the action of the lungs, which would otherwise lead to error. It must likewise be attended to, that a considerable quantity of humidity is continually poured out, to moisten the external or bronchial surface of the lungs, as well as through the whole ramifications of the trachea itself; the moisture arising from these sources being estimated, the quantity of liquid emitted by the lungs themselves will be in this manner reduced to a very small proportion. Besides, considering the very important uses of water in the animal economy, it is hardly probable that any considerable quantity of it can be evolved in this manner as excrementitious.

It will afterwards be rendered probable, that water is in many instances, perhaps at all times, and in considerable proportion, imbibed from the atmosphere, and carried into the circulating fluids by means of this very organ. Nevertheless, we completely agree with Mr Davy, " that the evolution of water from the vessels in the lungs is almost certain from numerous analogies;" and it is extremely probable, that by the aid of this fluid, the other gaseous matters extricated from the blood, are more completely eliminated from the system.

The increased temperature of the expired air may be readily demonstrated by means of a delicate air thermometer, fixed in a jar containing common air, and standing over water; the whole apparatus being of the same degree of heat as the surrounding atmosphere: on breathing the air in the jar by means of a bent tube, the thermometer is perceived to rise, while at the same time a diminution of the quantity of the air takes place. As the heat of the air expired must always correspond in a certain degree to the temperature of the thorax, it will therefore be always more expanded than previous to its inspiration.

Having in this manner investigated the changes produced on the atmosphere by respiration, to render the illustration more complete, we shall next attend to the effects of that function on the respirable gases.

All the simple gases are respirable in a certain degree; though oxygen gas is the only one that can be breathed for any length of time, it also, like the others, proves fatal after a certain period, though its mode of action is very different. The respirable property of oxygen gas being made known immediately after its discovery, it became thereby more frequently the subject of experiment than any of the other artificial gases.

M. Lavoisier performed some of the earliest experiments on this air. He inclosed a Guinea pig in a jar filled with pure oxygen gas, and kept it there during the period of seventy-five minutes; at the conclusion, on examining the air, he found it contained 159.50 grains of carbonic acid, and that a quantity of oxygen gas had disappeared, equal to 144.17 grains. By this experiment we see, that in the absorption of oxygen gas, and in the emission of carbonic acid, the respiration of oxygen gas is attended with similar consequences to those produced by the respiration of common air. Similar experiments to ascertain this circumstance, were likewise conducted by Dr Crawford, Beddoes, Watt, Priestley, and many others: in all of them the same result was given; but the proportion of these changes have been most accurately examined by Mr Davy. This philosopher discovered, that when pure oxygen gas is respired, that a less portion of it is absorbed, and less carbonic acid gas is evolved, than when the same quantity of common air is breathed: but this conclusion, it must be observed, is directly in opposition to M. Lavoisier's experiments; who affirms, that in every circumstance, whether the oxygen gas is breathed in a pure state, or combined with any other gas, that the same quantity of it is always absorbed, and the same quantity of carbonic acid gas is uniformly emitted: his words are, "soit que les animaux respirent l'air vital pure, soit qu'ils respirent dans la même air, melangé avec une proportion plus ou moins considerable de gas azote, la quantité de l'air vital qu'ils consomment est toujours la même, à de tres legers differences pres." Though the accuracy of Lavoisier is hardly, in any instance, to be questioned, in the present case there is, however, every reason to suppose, that his opinion is not wholly divested of the prejudice of preconceived theory. On the other hand, Mr Davy's experiments were conducted in a manner, that could perhaps insure a greater degree of accuracy; besides the result afforded by them is such as should be expected, on considering the highly stimulating property of the fluid under examination.

Mr Davy likewise respired hydrogen gas; by the experiments on this part of the subject it appears, that a quantity of that gas is likewise absorbed, and that carbonic acid gas is emitted from the lungs, whether the air respired contains a portion of oxygen gas or not. We have already seen, that the experiments of Spallanzani likewise tend to the same inference. That celebrated naturalist has also found, that in amphibious animals nearly the same changes are produced on the air by the functions of the skin; only he supposes, that the quantity of oxygen gas absorbed by the surface, is greater than what is taken up by the lungs: this circumstance he ascertained, by cutting out the lungs of those animals, and then confining them in a certain portion of air. He perceived likewise, that they uniformly died more quickly by being covered with varnish, than by having their lungs extracted. But from the best conducted experiments on the nature of the cuticular functions in man, it does not appear, that a similarity, far less a complete alternation, in the changes produced on the atmosphere by the functions of the skin and lungs, ever takes place in a state of health.

The gaseous oxide of nitre, (nitrous oxide gas), is the only compound gas that is fit for respiration. Mr Davy found, from repeated trials by respiring this air, that more oxygen gas disappears, and more azote is supplied, and a less quantity of carbonic acid gas and water are evolved, than during the respiration of the same quantity of atmospherical air. In this manner the changes produced on this gas by respiration, are found to be similar to those effected by breathing common air; the fluids that are absorbed, and those excreted in both experiments, only differ in proportion. It is extremely probable, that at least a quantity of this gas, in its entire state, is absorbed by the lungs; the peculiar effects it shews on the system seem to prove this.

The other artificial gases are totally unfit for respiration, and even the attempt to breathe some of them is attended with much difficulty and danger. This is supposed principally to be occasioned by a spasmodic affection of the muscles connected with the glottis and epiglottis, whereby the passage to the lungs is completely impeded. When the unfortunate Pelatre de Rozier caused himself to be let down into a brewer's vat, containing a quantity of fermenting liquor, whereby the vessel was filled to the brim with carbonic acid gas, the temperature of his body was manifestly increased, and he perspired more freely; he likewise felt a sensation in his eyes, that caused him frequently to shut his eye-lids; and when he attempted to breathe, that motion was prevented, in consequence of a strong feeling of suffocation; he felt giddy, and his ears tingled violently. He frequently repeated this experiment, and uniformly experienced a strong feeling of suffocation whenever he attempted to breathe the surrounding gas; but he respired freely on getting into the open air, though his lips remained of a purple colour; his limbs were weak, and he was unable to collect his ideas for some time. Mr Davy is the only person who gives an account of the effects of hydro-carbonate gas in respiration, probably the most pernicious of any of the irrespirable airs; his symptoms nearly resembled those described by Rozier, only they seem to have commenced earlier in the trial, and to have been more severe, and lasted longer. From the violent effects of these gases, and the repugnance of the glottis to give them admission to the lungs, it has been hitherto impossible to ascertain what effects respiration produces on them: probably no alteration in the constitution of these gases would occur in consequence of the action of this function. At the same time, it does not clearly appear how the symptoms described by De Rozier and Davy should originate solely from the difficulty experienced in respiring them. The admission of a small portion of either of these gases into the lungs, seems a more likely cause for the train of anxiety and insensibility described in both instances; and it is not improbable, that in that case an absorption of a portion of them does take place. In this manner they will be sooner and more immediately applied to the nervous system, and their peculiar influence will be thereby more quickly propagated. Dr Powel has seemingly established this opinion; he made an animal to breathe through a canula placed in the trachea, below the muscles of the larynx; and yet he was destroyed presently by the carbonic acid gas. See Minutes of a Society, &c. p. 139. Fontana, however, seems to think, that hydrogen and azotic gases are not immediately poisonous to animals, but that carbonic acid gas propagates its deleterious effects, by directly destroying muscular irritability. It will be rendered more evident afterwards, that the excretion of carbonic acid from the system, is one of the most important purposes of the pulmonary functions in a state of health ; therefore, the admission of hydro-carbonate or carbonic acid gas into the circulating fluids, by altering their chemical combinations, and causing an accumulation of this deleterious matter in the system, will thereby greatly aggravate the effects of their otherwise poisonous qualities. How far their baneful influence may be propagated by their immediate impression on the surface of the pulmonary system, independent of absorption, is not easily ascertained ; but it seems probable, that it is in this manner that death so speedily follows in consequence of inspiring them.

In the former part of the investigation, the changes which the respirable gases undergo by the action of the lungs, has been shewn in a general way ; and, as it is evident, that the occasion of these changes is entirely owing to the blood circulating through that organ, it seems therefore proper to premise a few general observations respecting the nature and properties of this fluid, as preparatory to an investigation on the second division of the subject.

The blood is a compound fluid mass, circulating through the body in tubes or vessels, from which its organs are supplied with nourishment, and from it all the other humours of the system are secreted: it is principally propelled by the power of the heart in man and other animals possessed of red blood, and this power is continued by the action of the vessels in which it is circulated. In this way, it is continually changing place, and it has been calculated, that in the space of ten minutes the whole mass of blood passes through the lungs: as this circumstance takes place repeatedly in the course of twenty-four hours, an intimate connection is thereby established between that organ, and every other function of the system. The blood is apparently an homogeneous liquid, most usually of a red colour, and of a specific gravity greater than that of water, being as 1.0527 to 1.0000; it is not of the same consistence in every animal, nor in the same animal at different times; but its tenuity is so great, that it circulates through vessels that cannot be filled with the finest coloured injection. When fluid blood is examined with a microscope, globules are perceived in it, which are supposed to be the integral particles of this fluid; their diameter is extremely small, being between $\frac{1}{2000}$ to $\frac{1}{3000}$ of an inch, and they are supposed to alter their figure, and even to divide into more minute globules according to the diameter of the vessel they are about to pass through.

Mr Hewson's experiments proved to him, that the integral particles of the blood were flat, not globular; that each particle consists of an external vesicle, containing a minute red particle in the middle, and that they are not perforated according to the opinion of some physiologists, nor do they alter their shape by the action of the vessels; but he supposes, that their size varies in different periods of life: it is however to be observed, that this is a part of the subject in which a person is extremely apt to be deceived, even when the investigation is prosecuted with the greatest caution; at the same time, the known accuracy and abilities of Mr Hewson, entitle his opinion to a considerable degree of confidence.

When a portion of the blood is taken from the system, or happens to stagnate in the vessels in consequence of local disease, or death, it is found to separate into parts different in their consistence and properties. The first is a firm reddish mass, called coagulum, crassamentum, or clot; this is surrounded with a greenish-coloured liquor, named serum, a name obviously derived from its sensible qualities: it is owing to the variation in the quantities of this liquor at different periods, that the consistence of the blood is not found always the same, and this must likewise induce an occasional variation of its specific gravity. These principles, Mr Hunter supposes, are not essentially different in every animal. The separation of the mass into coagulum and serum, is in consequence of it having been previously congealed, an appearance the cause of which has not been hitherto explained.

Mr Hunter discovered, that cold of itself does not hasten the coagulation of the blood, but that, when it is confined within a vacuum, it always coagulated sooner than an equal quantity of this fluid exposed to the air. Mr Hewson perceived, that the coagulation of blood is not owing to rest alone; and it even coagulates after having been frozen and then thawed; neither is its coagulation prevented by diluting it with water: these, and several other circumstances, not immediately connected with this part of the subject, induced Mr Hunter to believe, that the blood is possessed of a vital principle,—an opinion that was perhaps originally entertained, in a philosophical point of view, by Dr Willis. When blood is received into a bason, as in the common operation of bloodletting, it immediately begins to coagulate, and afterwards to separate into the parts already mentioned: besides the clot, and the serum in which it swims, there is always a quantity of vapour flying off as the mass cools; this vapour consists almost entirely of water, and probably never holds any principle that does not abound in the other parts of the blood. On washing the coagulum in water, it gradually loses its red colour, and becomes of a whitish yellow appearance; at the same time, the matter which had occasioned its colour, is perceived to be imparted to the water. This colouring matter being allowed to deposite, and then being collected and dried, is found to be completely soluble in acids, though Mr Hunter found that alkalis have but little effect upon it: by more accurate experiments, this matter has been ascertained to be sub-sulphate of iron, united to a small portion of albumen; and it is this particular metallic compound that occasions the red colour of the blood.

The water in which the clot has been washed, still contains matters that had been communicated to it by that operation; it is found to turn the infusion of violets to a green colour; when slowly evaporated in the sun's rays, it thickens, or a substance is irregularly precipitated through it in the form of flakes, which, from its resemblance in appearance and properties to the white of eggs, has been named albumen; when the evaporation is carried on till dryness, and the residuum digested with spirit of wine, a part of it is dissolved; this solution changes the blue colour of vegetables to a green, plainly shewing, that it contains an alkali; a precipitation is likewise produced by adding an acid to the solution, and this precipitation has been found to consist of soda, united with the acid employed.

The coagulum that remains after washing, possesses a great degree of elasticity, is insoluble in water or alkohol, and does not suffer any changes by exposure to the air, but what is occasioned by the evaporation of its water, and the consequent loss of its elasticity: it does not undergo the putrid fermentation, even when kept in circumstances favourable to that process, but it is decomposed by sulphuric and nitric acids. This substance is called *fibrina*, from a similarity in its properties to the principal substance in the composition of muscular fibres: this is the part of the blood that is supposed to be peculiarly adopted for repairing the waste of the system; from this circumstance, Bordeu called it fluid flesh, and, with a similar notion, Paul Zacchaia had long before asserted, that "caro nihil aliud est quam sanguis concretus." By this analysis, the clot is found to consist of albumen, sub-phosphate of iron, soda and fibrina.

The serum or whey has a peculiar faint smell, and possesses the property of changing vegetable blue colours to a green; this shows that it contains an alkali in solution, and this alkali has been ascertained to be soda. Serum coagulates at the temperature of 156° of Fahrenheit; but when diluted with more than six times its quantity of cold water, it cannot be coagulated by heat. The coagulation, from its similarity to the whites of eggs, has been denominated albumen; before coagulation, it is soluble in water; and even when dried by slow evaporation, it assumes its primitive form, by the addition of a quantity of that liquid : and this solution is capable of being coagulated by alkohol and acids. Nitric acid acts most powerfully on coagulated albumen, by which both substances are decomposed. Albumen very rapidly putrefies. When an incision is made into coagulated albumen, it is perceived to consist of cells, from which there pours a quantity of fluid, resembling the serum in its properties ; it has therefore been denominated serosity. If this fluid, or the serum, after the precipitation of the albumen, be evaporated to about one-third of its original bulk, and then set apart, it will be found gradually to coalesce into a mass, having all the properties of jelly. Serum is in this manner found to contain jelly, or gelatina in technical language. Jelly is always transparent, soluble in water, but insoluble in alkohol, and, in either state, it is insipid ; it readily putrefies, and, according to some, it is supposed to undergo the acetous fermentation. When a solution of gelatina is mixed with some of the solution of tannin, or the tanning principle, a whitish precipitation takes place. This precipitation is found to be possessed of cohesion and elasticity. It is insoluble either in water or alkohol, and does not undergo the putrefactive process. When the serum is freed of the albumen, and allowed to remain at rest in any vessel, its inside will be found covered with a variety of crystals of different salts. By examination, these have been found to consist of soda, carbonate of soda, muriate of soda, phosphate of soda, and phosphate of lime. It has been supposed, that a portion of the soda exists in the blood in a caustic state, the carbonate being probably formed during the analysis.

Besides these principles, the blood contains other matters. Like every animal substance, sulphur either exists as a component part of it, or is generated somehow or other by their decomposition. When a piece of silver is exposed to the fumes of blood, or is used as an utensil in its analysis, it is found to acquire an incrustation of a black colour, similar in every respect to the rust with which images of that metal are seen covered in churches. This has been long considered to be a sulphuret of silver; but M. Proust has found, by a late analysis of this substance, that the sulphur exists in it in the state of hydro-sulphuret, and that it is likewise united with ammonia: thus, we have two additional principles to those detected in the coagulum and serum. The following are therefore the principal matters in human blood, though others besides these have been discovered in that of other animals; and it is not unlikely, that there may be also some others in that of man, which have not been yet revealed; meantime, it has been shown to contain water, fibrina, sub-phosphate of iron, albumen, gelatin, soda, phosphate of soda, muriate of soda, phosphate of lime, carbonate of lime, sulphur, and ammonia; and to these may be added, light, heat, and electricity.

M. Fourcroy discovered, that the blood of a fœtus differs materially from that of an adult; it being of a deeper red colour, and not so readily altered in that respect by exposure to the air; nor does it contain a matter concrescible by cold; it rather coalesces, like jelly; neither could he detect any traces of phosphoric acid in it; though it must be remarked, that if the red colour of the adult blood be owing to the presence of sub-phosphate of iron, this particular matter should also exist in the blood of the fœtus, though perhaps not in so great proportion as in that of a grown-up person.

From decomposing these matters, by heating dried blood in a crucible, M. Fourcroy found, that prussic acid was formed, and ammonia exhaled during the whole of the process. The fibrin, albumen, and gelatin, may be ultimately resolved into carbon, hydrogen, and azotic gases; and although in this way they seem to differ only in their proportions, in the composition of those primary matters, they cannot be reproduced by the reunion of them, even in the proportions they appear to have existed in the formation of each individual compound. The principles we have stated above, as composing the blood, are to be considered as that of a healthy person; as the proportion of these matters must be continually varying from disease, and, in many complaints, some of its principles the most essential to health disappear, while others of an adventitious nature are generated in their stead.

The blood which flows through the arteries differs in many respects from that which circulates in the veins of the animal. The colour of the former is more bright, and its capacity for heat is greater, according to the experiments of Dr Crawford. These are the most obvious characters which distinguish arterial from venous blood; but in many other circumstances they will be found to differ. Although no gaseous fluid appears to exist in blood, as it circulates through the arteries and veins, and when any gas (even the most salutiferous, when inspired) is mixed artificially with it in the living system, it proves immediately fatal; nevertheless, from several experiments, it has been ascertained, that such matters do exist, and that those in the venous blood differ from those which are combined with the blood in the arteries. It is likewise probable, that arterial blood contains a greater proportion of the electric fluid than any other part of the mass, it having been formerly remarked, that the atmosphere, when pure, is always in a positive state of electricity, but that, by respiration, this condition becomes negative; and, as will be afterwards shown, the changes effected upon the air being principally owing to the action of this fluid, it must therefore contain the greatest proportion of the matters which disappear from it. This part of the investigation will be rendered more distinct, by attending to the result of the experiments which have been performed with a view to ascertain this point. Fontana was the first who detected the existence of oxygen gas in arterial blood; and the experiments he performed to corroborate this opinion are perhaps still the most satisfactory. He observes, " J'ai eprouvé l'air inflammable qui n'était point diminué par l'air nitreux, et je l'ai laissé en contact avec le sang (arteriel), pendant trois minutes. Il a augmenté sur le mercure d'environ $\frac{1}{14}$; agité avec l'eau il a été sensiblement diminué, et a perdu environ $\frac{1}{20}$ de son volume primitive. Il s'est allumé avec l'explosion à l'approche d'une lumière. Avec l'air nitreux, il a donné 185. J'ai repeté l'experience en agitant le sang; l'air a augmenté de 14 parties à 18$\frac{1}{2}$; agité ensuite avec l'eau, il s'est reduit à 14$\frac{3}{4}$: il a fait l'explosion à la lumiere; et avec l'air nitreux il a donné 165.—See Opuscles Physiques et Chimiques, page 54. He likewise performed this experiment by means of atmospherical air and nitrogen gas, and in all of them he obtained a similar result.

The above experiment must be attended with some difficulty in the performance; but when it is conducted without admitting any communication with the atmosphere, it may be regarded as decisive. This is shewn by the diminution of the gas to which the blood is exposed, and the explosion that takes place when set on fire, as hydrogen gas only explodes by the addition of oxygen gas. Girtanner made several trials with a similar view, and the result in all of them is favourable to the correctness of the above statement. There is an account of one of these experiments copied by Hassenfratz in his Memoirs on Respiration, in the 9th vol. Ann. de Chim. p. 264; the following are the words of that author: "Le sang arteriel de l'artere carotide d'une brebis fut reçu dans une bouteille pleine de gas azote; le bouteille moitie remplie fut bouchée, le sang coagula, et prit une couleur tres foncée: en ouvrant la bouteille le lendemain matin, le gas azote qu'elle contenoit se trouva mêlé d'une petite quantité de gas oxygene, de sorte qu'une bougie y brula pendant pres de deux minutes." Dr Crawford has also shown, that hydrogen gas is absorbed, and phlogisticated gas is improved, by remaining in contact with blood extracted from an artery. These experiments, from the known accuracy of the author, tend greatly to corroborate the opinion of Fontana, which is farther confirmed from observing the effects produced in arterial blood by the action of the other artificial gases. When arterial blood is exposed to the air, it becomes dark coloured, approaching to deep purple. Fourcroy found, that when he left arterial blood in a vessel containing oxygen gas, it gradually lost its usual florid colour, and had then every appearance of blood which had been kept in contact with hydrogen gas, and that no addition of oxygen gas could restore its former scarlet colour. He also ascertained, that arterial blood lost its colour most rapidly when kept in contact with hydrogen gas; and in that case its appearance became similar to venous blood, kept in contact with the same gas. Dr Beddoes found, that blood taken from an artery became more florid by being kept in contact with carbonic acid gas, and that carburetted hydrogen gas rendered its colour still higher.

Arterial blood confined within the vacuum of an air-pump, was perceived by Dr Priestley to have lost its bright colour; and Mr Davy found, that by exposing arterial blood to the temperature of 200, oxygen gas could be obtained from it without the intervention of any other medium.

Venous blood, when exposed to the atmosphere, acquires a more florid colour. It likewise appears, from the experiments of Priestley, Crawford, and Hassenfratz, that when oxygen gas is confined over venous blood, it is diminished in quantity; but Dr Crawford perceived also, that it was vitiated in quality. Chaptal performed the same experiment, and on examining the oxygen gas that had been employed, he found that it was no longer fit to support combustion. These experiments tend mutually to elucidate each other; and though they do not shew that aërial fluids do really exist in the blood, they render the opinion extremely probable, that they are in one way or other connected in a state of intimate combination with some of its principles. Mr Davy found, " 1*st*, That when nitrous oxide is agitated in fluid venous blood, a certain portion of the gas is absorbed, whilst the colour of the blood changes from dark red to red purple. 2*dly*, That during the absorption of nitrous oxide by venous blood, minute portions of nitrogen and carbonic acid are produced, either by evolution from the blood, or from a decomposition of part of the nitrous oxide. 3*dly*, That venous blood, impregnated with nitrous oxide, is capable of oxygenation; and *vice versa*, that oxygenated blood may be combined with nitrous oxide."

Fourcroy put a quantity of bullock's blood into a vessel containing 70 cubic inches of oxygen gas, and allowed it to remain for thirty days; its appearance in that time had changed to a beautiful purple, and when shaken, it became bright scarlet; on examining the gas, he found it diminished in quantity, and what remained containing much carbonic acid. Dr Goodwin performed the same experiment on a smaller scale, and he perceived that the oxygen gas diminished gradually by the mercury ascending in the jar, and that the blood itself had thereby acquired a bright red colour. Mr Davy and many other chemists have conducted similar experiments, and all of them afforded the same result. Fourcroy confined a quantity of blood in contact with hydrogen gas for thirty days, in which time it entirely lost its bright colour, and became dark brown. When venous blood is exposed to the action of azotic gas, its colour undergoes no remarkable change, nor does there take place any diminution of the gas itself. Carbonic acid gas is but slightly diminished in bulk when confined over venous blood; the blood, however, becomes much darker in the colour. Venous blood acquires a fine red colour by remaining in contact with carburetted hydrogen gas, but less bright than the colour produced by exposure to oxygen gas; at the same time, a quantity of the gas disappears. This experiment was originally performed by Dr Beddoes, and has been confirmed by Mr Watt and Davy, so that there does not remain a doubt of the correctness of the observation. Mr Watt likewise found, that this gas has the property of retarding the putrefaction of the blood, and of animal matters in general.

Nitric oxide gas acts in a very powerful manner on venous blood, which it changes to a dark purple colour, and a considerable portion of the gas is thereby absorbed. But the following experiment by Mr Davy, is much more decisive respecting the gases combined with venous blood than any of the former. " The blood was received into a sheep's bladder, and never came in contact with any air during the experiment. The bladder was inserted in a vessel of water heated to 112°, and the gaseous products received by a pneumatic apparatus; they were carbonic acid and aqueous vapour." And experiments of a similar description by others, shew that the quantity of carbonic acid gas emitted by venous blood, is increased by placing it in contact with oxygen gas.

From these experiments we perceive, that arterial blood contains a portion of oxygen gas combined with it; and that carbonic acid gas is produced from venous blood by similar experiments. But in none of these instances is there any proof of the emission of hydrogen gas from blood taken from either sets of vessels. The changes of colour in the blood, and of the quantities and properties of the air employed in the above experiments, seem to be entirely owing to the degree of affinities existing between them, and the matters of which the blood is composed. It is in this way that the blood circulating in the arteries is found to differ most essentially from that contained in the veins. The cause by which this difference is kept up, falls next to be considered.

At an early period of philosophical observation, blood issuing from a wounded artery, was distinguished by the brightness of its colour, from that flowing in the veins. Lower observed, that the blood contained in the right cavity of the heart, was much darker in its colour than that which flows through the left ventricle of this organ,—an observation which proves, that the alteration which the blood undergoes must be in its circulation through the lungs: accordingly, the cause of this difference of colour was imputed by Mayow to the absorption of the nitrous part of the atmosphere, as he called it, by the blood circulating through the superficial ramifications of the pulmonary artery. This opinion has been revived since the discovery of the constituent principles of the atmosphere; oxygen gas being substituted for the peculiar expression of its original author. But admitting the correctness of this opinion, and that the florid colour of arterial blood depends on the absorption of oxygen gas from the air during respiration, it will be found a matter of considerable difficulty to show, in what manner this gas gets into the course of the circulation; we are not instructed by anatomy of any direct inlet for its admission; and although the air be almost in immediate contact with the blood, as it circulates over the surface of the lungs, where only the finest membrane intervenes, still it is not easy to conceive, how the affinity that subsists between the particles of the blood and the component parts of the atmosphere, should operate in such circumstances as to cause a disunion of the latter. The well-known experiment of Dr Priestley, where venous blood was confined in a bladder, previously moistened, and which had its colour rendered brighter, by being held over oxygen gas, will not apply to the living system. Physiologists have not found, that any transudation takes place, even through the most delicate membrane, while the animal continues alive and in health; and how a fluid, even of the tenuity of oxygen gas, should permeate vessels which are always either in a state of distention or muscular contraction, it is almost impossible to comprehend. Dr Goodwin's experiments seem also to militate strongly against this opinion: he "dissected the cellular membrane from the small veins of several rabbets, and confined the blood in them by ligatures; and then conducted a small stream of oxygen gas to the coats of the vessels: in some of them the blood became a little florid, but in others there was no distinct change, although the stream of air was conducted for two minutes." A change in the colour of the blood, in its passage through the lungs, is generally supposed to arise in consequence of the action of oxygen gas upon the iron contained in that fluid. This probably takes place to a certain degree, and serves to assist in forming the state of combination in which it is usually detected.

It has likewise been imagined, that oxygen gas unites immediately with the serum, and that its influence is imparted, through this medium. But we shall afterwards have occasion to state some circumstances by which it would appear, that the air absorbed unites directly with every part of the mass, and in this way it probably acts, by adapting it to reflect the luminous ravs differently, by a variation in its powers of refraction.

From the experiments of the philosophers already mentioned, it is evident, that a portion of the nitrogen of the atmosphere is likewise absorbed in respiration: but although both the principal gases of atmospherical air disappear during this process, it seems probable, from the great disproportion of the quantity of those gases which are absorbed, that the air, in its entire state, does not combine with the blood; were this the case, the force of attraction between that fluid and the air must have been different to what it is. This opinion appears likewise to be corroborated, from what takes place on the exposure of venous blood to the air, oxygen gas being the only part that unites with it; and although oxygen gas has been recovered from arterial blood, there is no instance recorded where atmospherical air has been procured from this fluid, which must otherwise have been the case. Abildgaard, in the 36th volume of the Annales de Chimie, observes, that in every instance he found the carbonaceous matter of venous blood to exceed in proportion that contained in arterial blood; but blood circulating in the veins, has been only found to contain carbonic acid gas.

The venous blood of the system is circulated through the lungs by the pulmonary artery, which returns its contents to the pulmonary veins, and it is by these carried to the left auricle of the heart. The changes which the blood undergoes in the lungs, evidently take place in the course of its transition from the pulmonary artery to the veins; in the former it appears of the dark red colour peculiar to venous blood, whereas in the latter it has acquired the bright scarlet colour of that which circulates in the arteries. The evacuation of carbonic acid gas has probably its exit by the exhalent vessels of the lungs, which, at every contraction of the heart, must be in a state of distention: but the manner how the air gets admission into the blood by inspiration, lays open a wide field for future investigation; and till this circumstance is ascertained, it will be in vain to expect an incontrovertible theory of the function of respiration. But that gaseous fluids do get admission into the blood during the performance of respiration, the facts we have adduced afford a satisfactory proof, and we shall afterwards have occasion to mention some circumstances, which render this more evident.

From the experiments performed on respiration, and the changes that are thereby effected on the atmosphere, we must consider this function, not only as necessary in attracting something useful from this element, but from the facts mentioned, it seems probable, that in this process the lungs act also as an excretory organ, in evacuating from the system a matter that would become hurtful by accumulation. It has been demonstrated, that oxygen and nitrogen gases disappear during the exercise of this function; but that carbonic acid is uniformly emitted, when common air, or when any artificial gas is breathed, whether it contains oxygen gas or not; it is therefore reasonable to conclude, that the excretion of this gas is one of the most important purposes of respiration; and although its formation does not seem to depend immediately on the absorption of oxygen gas, it is evident, that all the circumstances of this function are intimately connected with each other. This is likewise confirmed, by finding that more oxygen gas dissappears in respiration, than any other principle of the air; and as every aërial fluid in which it does not form a part, very speedily occasions death when respired, it is therefore justly considered as a principle essentially necessary for maintaining the due performance of this function.

Soon after the discovery of the composition of atmospheric air, Lavoisier promulgated an opinion respecting respiration, which, as it affords a very plausible explanation of this process, it continued long to be generally adopted: his theory was built on the facts he had ascertained by his own experiments, conducted with a view to elucidate the function. He supposed, that the greatest share of the phenomena of respiration is completed in the cavity of the lungs themselves; that the carbonic acid is there formed, by the carbon excreted from the blood having combined with the oxygen gas of the air. He likewise imagined, that a portion of this gas enters into union with a quantity of hydrogen gas that is supposed to be at the same time separated from the blood; the proportion of oxygen gas that disappears, being exactly corresponding to that which is necessary for the formation of the carbonic acid gas, and the water emitted with the expired air: this is the general purport of his theory, though, in his different essays on respiration, he occasionally varies this opinion in a slight degree. But it has been shewn, that oxygen gas is not the only principle absorbed from the atmosphere in respiration; and it has likewise been demonstrated, that the absorption of oxygen, and the extrication of carbonic acid gases, are not immediately depending upon each other. The theory which Dr Crawford suggested upon this subject, does not differ materially from the above. He sets out by stating the chief causes of difference between arterial and venous blood, as owing to the existence of a quantity of hydro-carbonate in the latter; and that during respiration, he supposes this compound unites with the oxygen gas of the air inspired, and thereby forms carbonic acid gas and water. In opposition to this opinion, it must be objected, that the existence of hydrogen gas, or any of its compounds, has never been detected in the blood; while, on the other hand, it has been demonstrated, that carbonic acid gas does abound in venous blood; and it does not seem possible, according to either of these opinions, that the union of hydrogen and oxygen gases could produce either water or carbonic acid in such circumstances. The particular theory of Lavoisier, either in its original form, or with the improvements suggested by Dr Crawford, fails most completely in explaining many other important uses of the air in respiration; it restricts the functions of the lungs to that of an excretory organ; besides the whole is founded on data by no means capable of demonstration, in the manner alleged: this will readily appear from the statement of facts above mentioned, and the occasional explanations we have given of them.

La Grange has suggested a theory in explanation of respiration, which has been supported by Hassenfratz and other celebrated names; it differs in many respects from the former opinions, and goes a step or two farther in elucidating this function. The alteration that takes place in the chemical principles of the air, are not supposed to be different from what has been already stated; but this theory disagrees widely, as to the manner how the matters evolved in respiration are supposed to be formed in consequence of these changes. According to this opinion, the oxygen gas of the air inspired unites with the venous blood circulating through the lungs, which thereby acquires a more florid colour; during the course of circulation, it is supposed to unite with carbon and hydrogen gas; with these it forms the carbonic acid gas and water, which are uniformly found mixed with the expired air: in a certain degree, this theory corresponds with the changes effected on the principles of the atmosphere; though, in other respects, it does not afford a satisfactory explanation of this function; besides, it assumes the existence of hydrogen gas in the venous blood as certain. But, although the above theory appears so far correct, it cannot be acceded to its author, that the quantity of oxygen gas absorbed is merely sufficient for the formation of the excrementitious fluids found in the expired air; indeed, the purposes of respiration are more than what become evident by this explanation; this is manifest, independently of any other circumstance, by finding, that other parts of the atmosphere besides oxygen gas are absorbed, and that carbonic acid gas is emitted, when oxygen gas does not form any portion of the air inspired.

At an early period of pneumatic chemistry, it was conjectured, that the alterations produced in the blood by the air in respiration, were by no means fully indicated by the matters found in the air expired; this is rendered evident, by finding, that the blood emitted from the right ventricle of the heart, has its properties completely changed by circulating through the lungs, and that the chyle with which it had been mixed also disappears in the course of this transition: the chyle is the fluid which supplies nourishment to the system; and differs greatly in its nature from blood; it does not contain fibrina; this is the substance of the blood which Mr Hunter and other physiologists suppose to be the principle most essential in repairing the waste of the system; till chyle therefore acquires this property, it cannot answer the purposes of nutrition, provided this opinion be correct. But there are many reasons to induce a belief, that every principle contained in the blood, answers this purpose occasionally; besides, fibrina has not been discovered in the composition of every description of animal matter; on the contrary, it only abounds in the muscular fibre, an organ perhaps as immutable as the bones.

M. Fourcroy has shown, that fibrina is ultimately compounded of a greater proportion of nitrogen than what is contained in any other principle of the blood; its carbon and hydrogen are less in proportion, and the oxygen it contains is very trifling. By Mr Hatchet's experiments, it is ascertained, that by diminishing the quantity of nitrogen, and at the same time communicating a portion of oxygen to fibrin, it assumes the properties of gelatin: fibrin therefore differs from that substance principally, by containing less oxygen and hydrogen, and a greater proportion of nitrogen. It is to be remembered, that gelatin is the most abundant principle in the blood of the fœtus; and it is probably also the most abundant principle in the blood of all young animals, especially while they continue to be nourished by their mother's milk; and at every period of life, gelatin enters more generally into the composition of the animal system than perhaps any other matter. At an early period of life, animals grow much quicker in a given space of time than at any after period,—a circumstance which clearly proves, that in the formation and growth of the body, the gelatin principle of the blood is of the greatest importance. Albumen also exists copiously in the blood: it, too, is capable of being converted into a substance like gelatin, by the addition of a quantity of diluted nitric acid. Albumen forms the coagulable part of the chyle; and it has been supposed, that it is with this portion of that fluid, that the nitrogen gas absorbed in respiration combines; while perhaps a considerable portion of the oxygen gas absorbed unites with the other principles of the blood: but the farther assimilation of the chyle is probably in a great measure performed by the peculiar action of the blood-vessels themselves, as it circulates through their minute ramifications; the blood having been found to contain many matters whose origin cannot be accounted for, by the knowledge that has been yet acquired of the animal economy, either in respect to its functions, or from the general nature of alimentary substances. It has been hitherto found impossible to point out the precise changes which the chyle undergoes by respiration; it is observed to acquire the properties of the blood in its circulation through the lungs; and it is evident, that these changes are chiefly effected by the absorption of oxygen and nitrogen gases from the air; but in what precise proportion, or with what part of the chyle these enter into combination, remains yet to be discovered.

Oxygen enters but sparingly into the composition of animal matters; carbon, nitrogen, and hydrogen abounding in proportion, according to the order enumerated, the former being most copious. Matters that have already served an useful purpose in the system, but which become unfit for the exercise of any function, are re-absorbed by the lymphatics, and are thus mixed with the venous blood along with the chyle, and in this manner are eliminated in passing through the lungs. The quantity of oxygen gas that disappears in respiration is probably the chief cause that operates the necessary changes, in rendering those matters fit for excretion, independently of its effects in converting the chyle into the nature of blood; this is implied, by the existence of that gas having been detected in the arterial blood, after the sanguification of the chyle. It is likewise probable, that the combination of oxygen gas with the excrementitious matters of the system is effected in the minute vessels; and to this cause the appearance of carbonic acid in the blood contained in the veins is to be imputed. In this way, we perceive how the absorption of oxygen gas is not necessary for the immediate excretion of carbonic acid, and why that gas may continue to be evolved for a short time, when oxygen gas is not inspired. By the same facts, we likewise comprehend why the quantity of oxygen gas absorbed commonly exceeds the proportion necessary for the formation of the carbonic acid excreted. It has been already observed, that the real state in which the aërial fluids exist in the blood has never yet been determined. Aërial fluids have not been openly detected in the mass during circulation; yet the presence of oxygen and carbonic acid gases in different portions of it, has been demonstrated by many decisive experiments: probably the pressure of the mass of blood, and the force and action of the blood-vessels themselves, prevent in a great measure these matters from assuming the aërial form: this is rendered probable by finding, that the carbonic acid assumes the form of a gas, immediately on reaching the external surface of the lungs.

Besides the pulmonary system, the blood is farther purified by the functions of the skin and kidneys; and it has been imagined, that the offices of the two first-mentioned organs are pretty similar in this respect. Cruickshanks has shown, that carbonic acid gas is copiously emitted from the cuticular surface in man; but that the air is absorbed or decomposed by that organ, has not been demonstrated. The matters discharged from the kidneys have their bases chiefly constituted of azote and saline matters, that are no longer of service in the functions of the body. In like manner, we have seen, that the discharges from the lungs and skin contain a greater quantity of oxygen in their composition; that they are principally aëriform, and are in this manner better fitted to be discharged by those organs. In this way, the agency of the pulmonary and cuticular discharges is supposed to be occasionally reciprocal in a certain degree; and it is observed daily, that the action of the kidneys frequently becomes increased, when any cause impedes the natural function of the skin. In such instances, it is probable, that the nature of the matters secreted do thereby undergo a considerable alteration. In this account of the theory of respiration, we have taken no notice of the watery vapour which is generally supposed to be emitted along with the carbonic acid; 1st, Because, from the reasons we have already stated, it does not appear that the quantity excreted in this way is so abundant as has been generally supposed; 2dly, The existence of hydrogen or its compounds not having been discovered in the system, it does not readily appear, how this liquid could be formed in consequence of the immediate absorption of oxygen in respiration; 3dly, The temperature of the body not being equal to effect that combination, therefore any water that does appear in the air expired, is rather to be considered as part of the moisture belonging to the surface of the lungs, or what is necessary to assist in the excretion of the excrementitious gas.

Upon the whole, the immediate effects of respiration may be considered, in the first place, as operating a considerable change on the blood circulating through the lungs, converting venous into arterial blood. This it does, by affording an outlet to the carbonic acid of the venous blood, which thereby acquires the colour of that in the arteries, while a quantity of oxygen and nitrogen gases are absorbed from the air inspired; nearly the whole of the latter and a part of the former of these gases combining with the constituent parts of the chyle, convert it into the nature of nutritious blood; and, secondly, the excrementitious matters of the system are rendered more capable of excretion, by the combination of the remaining portion of oxygen, in its union with the superfluous matters of the different organs.

But, besides that the air absorbed in respiration is to be considered as the primary cause of the assimilation of chyle, and as the means of assisting the discharge of matters that would become noxious by remaining in the system; this function likewise acts mechanically in assisting the circulation of the blood, and chiefly in propelling it through the viscera, where the veins are destitute of valves, and through the sinuses within the cranium. There is also another remarkable effect which is supposed to arise in consequence of the decomposition of the air in respiration, the temperature of animals being imagined to be owing to this circumstance. It is a subject highly important, and of considerable intricacy: on that account, it claims the greatest attention in an investigation of its phenomena. We shall therefore proceed to treat of it in a separate section.

SECT. II.

OF THE TEMPERATURE OF LIVING BODIES.

ALTHOUGH the heat of animals differing in species is perhaps in no instance precisely the same, still there is observed to be a permanent temperature peculiar to each, which seems in a certain degree independent of the variations of the temperature of the atmosphere. That of man varies from 94° even to 104° of Fahrenheit; 98° being the medium standard in a state of health. The permanent heat of animals has been imagined to be kept up by caloric, communicated to the system through the medium of the circulating fluids,—an opinion which has been supposed to be confirmed by the recent discoveries in the function of respiration. This idea seems to have been entertained at a very early period: Fernelius, speaking of the purposes of the air in respiration, says, " Inspiratione aërem introducimus qui non modo corpori refrigerationem, (hæc enim satis posset aliunde comperire), sed pabulum quoque sumministrat.—Maxime id suffocatur et perit, nisi aëre et respiratione juvatur, non quod a refrigeratione, sed quod *idoneo caloris et spiritus alimento distilletur.*"—Lib. iv. cap. iv. Medicinæ Univers. The following quotation from Aristotle's work *De Anima*, affords an unquestionable proof, that this opinion must have originated with him: "Jam eo qui respiratur, utitur natura, ad duo opera, sicut lingua ad justum et locutionem, quorum justus necessarius est, unde et pluribus inest interpretatio autem ut bene fit: sic et spiritu et ad calorem interiorem tanquam necessarium." We shall therefore proceed to examine how far the phenomena can be accounted for by this theory.

Mr Saumarez says, that in every instance, blood issuing from the left cavity of the heart is found to be warmer than that taken from the right ventricle. But, from the observations of Mr Coleman, in his Treatise on Suspended Animation, this circumstance seems rather doubtful. He found, that the temperature of the left ventricle of the heart of a cat was only 97°, while the right ventricle was two degrees higher; but the heat of this cavity exceeded that of the other four degrees in the course of fifteen minutes after the experiment had commenced. And Mr Cooper has uniformly met with a similar result, in a variety of experiments he made to determine this question; the heat of venous blood being always higher than that contained in the arteries. Mr Coleman's opinion is delivered in the following words, in the 43d page of his Treatise above mentioned: "From frequent repetitions of this experiment, (such as we have just stated), it uniformly resulted, that although the temperature of both sides of the heart was equal, yet the heat of the blood in the right side exceeded that of the left from one to two degrees." He imputes the lower temperature of the blood in the left cavity to its communication with the air in the lungs in respiration. It is generally allowed, however, that Dr Crawford has successfully shown, that the blood which passes from the lungs to the heart possesses a greater proportion of absolute heat than that which circulates from the heart to the lungs through the pulmonary artery; and that it has been demonstrated by the same ingenious philosopher, that the comparative heat of florid arterial blood is to that contained in the veins as 11½ to 10; and as this superior quantity of heat appears to have been acquired by the blood in passing from the lungs to the left ventricle of the heart, it is reasonable to conclude, that this must be effected in consequence of the changes it undergoes by the decomposition of the atmosphere in respiration. During this process, Dr Crawford supposes, that a quantity of absolute heat is separated from the air, and absorbed by the blood circulating through the lungs. This fluid, in its progress through the system, parts with this elementary fire, a small portion of it being at the same time combined with those particles which impart the inflammable principle to the blood; the rest becoming redundant, is converted into moving and sensible heat.

It has been shown, that the atmosphere necessarily contains a considerable quantity of caloric, in a state of intimate combination; it may therefore be supposed, that the evolution of heat from the air, must necessarily take place as a consequence of a diminution in its capacity for that element, this being the supposed effect of the changes it undergoes in the lungs. This hypothesis, respecting the cause of animal heat, does not materially differ from the opinion that was originally entertained on the subject by Dr Black, and which was afterwards ingeniously supported by Lavoisier: but as Hassenfratz justly observes, that were the temperature of animals entirely depending on the decomposition of the atmosphere in the lungs, according to the theory entertained by these philosophers, that organ must at all times have been much higher in temperature, than any other part of the body,—a circumstance that is by no means confirmed by experience, as the region of the heart enjoys a degree of temperature only more constant, but not exceeding that of the extremities; this objection has been supposed to be obviated by the capacity of the arterial blood for caloric having been discovered to be greater than in that which circulates through the veins, of course, it requires an higher degree of heat to raise it to an equal temperature; but, admitting the accuracy of this proposition, and that animal heat depends on the decomposition of the air in respiration, the more recent experiments of Davy and Spallanzani tend to shew, that the original data are fallacious on which the entire theory is founded. For if a portion of the atmosphere be absorbed in its entire state, the caloric arising from its decomposition must be gradual, as it takes place in the course of circulation; therefore the quantity of heat disengaged in the cavity of the lungs, must be merely what arises from the absorption of oxygen gas uncombined. It is likewise to be inferred from what has been already premised respecting the temperature of the air respired, that a quantity of caloric equal to what originates from this source, is given off by each expiration. How far the permanent temperature of animals depends on the decomposition of air absorbed in respiration, is extremely difficult to determine, as we have no mode of ascertaining in what condition it is absorbed, or what the precise changes are which it effects on the circulating fluids; but an increase of temperature must follow the composition of matters in the system, having a less capacity for caloric than their constituent principles: it has been consequently supposed, that the evolution of caloric gradually takes place in the course of the circulation. In this manner, it may be supposed, that the uniform temperature of animals is occasioned by the decomposition of the atmosphere in respiration, and the effects of its principles being regularly the same on matters always, or nearly similar in their nature, such as the constituent parts of the blood. But, however plausible this theory may appear, and although it may seem to agree with the leading facts regarding the changes produced on the air by respiration, there are many circumstances that incline us to believe, that animal heat is not to be entirely ascribed to this process; as, were this the real source of animal heat, it would seem in that case probable, that the surface of the body and extremities should enjoy the most invariable temperature; but which is refuted by experience. The cause of the temperature of animals perhaps does not admit of an explanation in the present state of our knowledge, yet a statement of some of the most prominent exceptions to the above theory merit a consideration, and may lead to a farther elucidation of this interesting subject.

In the alteration of the state of the blood, which immediately succeeds each inspiration, there is probably an absorption of a considerable portion of caloric by the matters excreted from the system, on their assuming the gaseous form, this being necessary for the complete evolution of the carbonic acid, and even the vapour which is expired; and it has been doubted, whether or not a greater proportion of caloric disappears in this way, than what is procured from the immediate decomposition of the atmosphere.

But were the temperature of living animals entirely owing to the caloric evolved from the decomposed air, by the function of respiration, the vicissitudes of the weather, and the changes of seasons, would not in that case produce corresponding variations in the heat of animals. Thus in a dense atmosphere, when a greater proportion of oxygen and nitrogen gases are contained in a given volume of it, the temperature of animals should be proportionally increased, as the same volume may be supposed to be inhaled in every instance, and that consequently a greater proportion of these fluids will be decomposed in the lungs. Again, when the atmosphere is in a rarefied state, the proportion of its constituent gases being therefore smaller in a given portion of it, we should expect, that the heat of the system would be in that case diminished, but we find by experience that no such uniformity takes place. In the cold season, ingenious methods are had recourse to, on purpose to retard the egress of caloric from the body, after it has been acquired; and in hot weather, its temperature is diminished by exposing the surface to the freer access of the air. It has been supposed, that in winter the superabundant caloric is abstracted as soon as extricated by the lower temperature of the surrounding air, and that in summer it is accumulated, the air being warmer at that season: but the supporters of this opinion must allow, that if the living body be capable of communicating caloric to substances in a manner similar to what occurs in inert matters, that it must be also capable of receiving sensible heat from these; and it will therefore have a permanency of temperature in many instances, independent of respiration. It has been already stated, that Spallanzani has determined by experiments, that in some classes of animals, a greater quantity of oxygen gas is absorbed by the skin, than what disappears during respiration: yet of those very animals (snails and amphibia) it is known, that the skin is always lower in temperature than any other organ; and in warm-blooded animals, the temperature of the skin is more apt to vary than any other part. In the same way, it is perceived, that certain organs are more apt to vary in their temperatures than others: thus, the external parts in general, and the extremities, are frequently chilled to a degree that would prove fatal, were the heat of the internal organs so diminished; on the other hand, these remain at the natural standard, when the former are heated many degrees higher.

But animals of the same species do not enjoy an equal temperature at every period of life. According to Schrieberus, it is greater in the infant than the adult state; the difference being about two degrees; and in old age it is less. This seems to have been observed by the earliest writers on medicine. Still it is not satisfactorily explained on the modern theory of respiration; as it is probable that a quantity of caloric will be set free by means of this function, at every period of life, equal to the mass of the system to which it communicates its effects. In Mr Hunter's Treatise on Animal Heat, p. 101, he observes, "when a man is asleep, he is colder than when awake; and I find in general, that the difference is about one degree and an half, sometimes less. But this difference in the degree of cold between sleeping and waking, is not a cause of sleep, but an effect; for many diseases produce a much greater degree of cold in the animal, without giving the least tendency to sleep. Besides, all the operations of perfect life, as digestion, sensation, &c. are going on in time of natural sleep, at least in the perfect animal, but none of those operations are performed in torpid animals."

But, granting the correctness of the explanation on animal heat by Dr Crawford, we are unable to account by it for the similarity of temperature in adults, the capacities of whose chests are so various, and who differ so greatly in the frequency of respiration. There are also people whose circulation does not go on faster than at the rate of forty in a minute; yet their temperature is always found to be equally high as that of others, whose pulse is nearly double the velocity. Virey justly observes, in his Natural History of Mankind, that men living in a state of nature, as many of the native American tribes, and the children who have been occasionally discovered wild in different parts of Europe, are found to be capable of resisting severe degrees of cold without inconvenience, and which would prove fatal to men living in a more improved state of society; and it is to be observed, that the effects of respiration must be similar in both. The physical powers of savage men are likewise proportionally greater than those of the civilized and educated. Were animal heat entirely owing to the extrication of that fluid in the process of respiration, there are no circumstances in the distribution of caloric through the system, which afford an explanation of the cause of the increased temperature of local inflammation; or how there should exist a general morbid degree of heat in several diseases, especially in the last stage of fevers, when the circulation is weak. Seguin has shewn, that there is less oxygen gas absorbed by the lungs in the cold stage of an intermittent, than during a state of apyrexia; yet it is very commonly perceived, that even in that stage of the disease, a morbid augmentation of caloric exists. A similar appearance is observed in the temperature of people labouring under asthma, phthisis, pneumonia, and similar injuries of the lungs, where the decomposition of the atmosphere cannot take place in so perfect a manner as in a state of health.

Spallanzani found, that a marmot in a torpid state effected no change on the atmosphere, neither was it hurt by being confined in a quantity of carbonic acid, which instantly suffocated a rat which was immersed in it; nevertheless, the temperature of dormant animals is always higher than the heat of surrounding bodies, and they are known to have the property of resisting degrees of cold far below the freezing point. Lavoisier states, in his 2d Memoir on Respiration, printed in 1789, that a Guinea pig, confined for several days in a mixture of air containing 1 part of vital air to 15 of azotic gas, preserved its natural state of respiration; its circulation did not seem affected; and its temperature continued the same. In p. 92. of Mr Hunter's Treatise, he gives a very singular instance of the variation of temperature, seemingly in consequence of disease, and independent of respiration. His words are: "A very remarkable one fell under my observation, in a gentleman who was seized with an apoplectic fit; and while he lay insensible in bed covered with blankets, I found that his whole body would in an instant become extremely cold in every part, continuing so for some time, and as suddenly would become extremely hot: while this was going on alternately, there was no sensible alteration on his pulse for several hours." Similar variations of temperature have been likewise remarked in patients, in the last stage of hydrocephalus.

There is also another circumstance which militates strongly against the general opinion of the cause of animal heat. In experiments made by respiring some artificial gases, the temperature of the system does not seem to have been diminished; on the contrary, Mr Scheele expressly says, that he thought the heat of his body was increased, while he breathed a quantity of hydrogen gas; and De Rozier takes notice of the same thing, while he respired carbonic acid gas. The passions of the mind have likewise a remarkable influence in varying the temperature of the body, being augmented by such as act as a stimulus to the system, and it is diminished in a degree no less remarkable, by the agency of such passions as depress the energy of the mind. Indeed stimuli of every sort tend to accumulate caloric in the system, in a higher degree than what could be expected from their effects on the function of respiration, or even on the circulation of the blood. This is also proved by what is observed to take place in men labouring under certain mental disorders, as well also as when the system is affected by the influence of peculiar matters, as stimulant medicines, or when inebriated in a certain degree. It is also uniformly observed, that people recovering from asphyxia, acquire their natural temperature some time before respiration recommences, and it is always regarded as a favourable circumstance, and a prelude to a complete resuscitation.

Fishes and amphibious animals consume a considerable portion of air, nevertheless their temperatures seem to depend, in a great measure, on the heat of the medium in which they live. It is likewise to be observed, that those animals whose temperatures are generally highest, and who are capable of resisting great degrees of cold, are in general covered with some substance well adapted to retain caloric, as hair, feathers, wool, &c. Horses, dogs, oxen, and at least all the larger quadrupeds, enjoy a temperature superior to that of man ; yet in most of these we have specified the respiration is by no means so frequent, nor is the blood circulated in them with equal rapidity. The temperature of a beehive is even much greater than the human temperature, and varies occasionally, independently of the decomposition of the atmosphere.—See Hunter on the Animal Economy. Besides these remarks, it has been already observed in the chapter on Combustion, that an increase of temperature does not always follow a decomposition and fixation of any of the principles of the atmosphere. Spallanzani remarks, in page 318. of his memoir, when speaking of the changes induced upon the atmosphere by snails, " in this respect these cold-blooded animals resemble those with warm blood, only the last consume oxygen more rapidly, though in a less quantity than the former. If, for example, a small quadruped or a bird consumes in fifteen minutes 0.14 of oxygen gas, it requires a greater number of hours for a snail to effect the same consumption; but the snail will at last completely absorb the whole of this gas, while the quadruped or bird leaves at its death a quantity of it unconsumed." It is therefore to be inferred, that were the temperature of these different classes of animals depending upon the decomposition of the atmosphere in respiration, that such animals as were the subject of Spallanzani's experiments, must, in that case, have enjoyed the highest temperature, and that the dormant or periodical sleeping state of certain classes of warm-blooded animals could never have occurred in any circumstances of atmospherical temperature; as by the decomposition of the air, they must have been at all times supplied with a quantity of free caloric, sufficient to keep them at an uniformity of temperature, in every variation of climate. Eggs have also a power of resisting high degrees of heat and cold, and they enjoy a permanent temperature, even when their shells are varnished over, or when the atmosphere is excluded from them in any other way. There is always a point to be perceived in the thick end of a fresh egg, of a much higher temperature than any other part of the mass, and which is not abated or increased with the temperature of the air, nor does it disappear when excluded from that medium.

Vegetables likewise enjoy a temperature different from the medium in which they grow: it is much lower in them during hot weather, and they are warmer than the air, when its temperature does not exceed 56° of Fahrenheit. The sap of herbaceous plants does not freeze, till the heat of the air has been cooled down to 16° below the freezing point; and that of trees, not till the heat has descended below zero. This correspondence in the heat of vegetables with that of animals, has also been imputed to a similar cause, the decomposition of atmospherical air in vegetation. This process has probably a considerable effect in this way, as will become more evident when we come to trace the effects of the atmosphere on growing plants: but there are also anomalies in this branch of the subject, which do not admit of an explanation from the effects of this cause: indeed, were that opinion perfectly correct, there would in that case be no difference of plants from the effects of climate, and the same kinds and varieties must have been found in every latitude. It has been found, that trees stripped of their leaves, which analogists have supposed answer the same purposes in the vegetable economy as the lungs in animals, possess a certain permanent temperature: and the same property is observed to exist in the seeds of plants, as in the eggs of animals; they enjoy a certain temperature, and continue to be prolific even after they have been excluded from the access of the atmosphere for years; but after having been exposed to a degree of cold sufficient to freeze them, this property is completely destroyed, although every attention and care may be taken to restore them to their natural degree of heat.

Many other instances might be adduced to shew, that the heat of living matters depends, in a considerable degree, on circumstances seemingly unconnected with respiration, or the decomposition of the atmosphere by any other function; to what power this may be precisely owing, it is extremely difficult to say: the subject has engaged the attention of the most celebrated physiologists of the present day, without the question having been determined.

At one time an idea generally prevailed, that the heat of animals depends upon the function of the stomach; and it cannot be denied, that there appears an intimate connection between it and animal temperature; but for many obvious reasons, we rather regard the functions of that organ as the index of the healthy state of the system, than as the cause of the phenomenon under our consideration. The celebrated John Hunter bestowed much care in the investigation of this subject; and by his experiments on the dormouse he found, that living and dead animal matter acquired and losed heat nearly in an equal degree. But this result differs widely from what has been obtained from trials of a similar description by Dr Crawford; he having found, that a living and dead frog, confined in warm air, had their temperatures increased in a given time, but that of the latter was greatest; exceeding, in the course of twenty-five minutes, that of the living frog, by about 3°; and in another instance, when confined in warm water, in the space of eight minutes it had acquired 2° of more heat. But in opposition to his own experiments, Mr Hunter concludes, "that it is most probable, that it (animal heat) arises from some other principle; a principle so connected with life, that it can, and does act, independently of circulation, sensation, and volition, and is that power which regulates and preserves the internal machine." The ingenious and celebrated Dr Cullen, whose authority is of the very highest rank in every physiological inquiry, seems to have supposed, that animal temperature does depend somehow or other on the vital principle; and he supports his opinion with great ingenuity and force of argument. But although there are many circumstances to render this opinion very probable, we are still so little acquainted with this branch of physiology, that it is impossible to advance any thing certain respecting its powers in this respect.

The power which living animals so remarkably possess of resisting high degrees of heat, gave rise to an idea, that they have even a power of generating *cold* in certain circumstances.

Dr Boerhaave was well aware of this fact, and performed several experiments in order to determine its cause. This he did by shutting up living dogs in an heated oven, but obtained no decided result therefrom. Dr Dobson likewise conducted several experiments in the bath-room of the Liverpool Infirmary, to investigate this property, and he perceived, that the pulse and heat of the body were increased, though not in an equal degree, in every one who was subjected to these trials. In a delicate young man of an irritable constitution, the temperature was higher in the same space of time than in a robust healthy subject. But the circumstances which seem to confirm the above-mentioned opinion, were in consequence of some observations made by Duhamel and Tillet in 1761, when they were employed by the French government to undertake the destruction of a species of insect, which had attacked the grain in the territories of Angoumois. The method they pursued was, to expose the grain in an oven heated sufficiently to destroy the insect, without affecting the texture of the corn; for this purpose it was necessary to ascertain exactly the heat of the oven; and they readily found two girls, who went into the place, and marked the height at which the thermometer stood: when the heat of the oven was so high as 112° of Reaumur, they remained for ten minutes within it, and without experiencing any distress; and they remained in it half that length of time, when the same thermometer indicated the heat at 130°. Within a more recent period, there has been experiments conducted in this country, on purpose to explain this point with greater precision. Dr Fordyce and Sir Charles Blagden remained for some time in a room heated to a much higher temperature than in any other instance, without having perceived a corresponding increase of heat in their bodies; since that time the subject has been regarded as being determined.

However, it does not appear that these experiments afford a decisive proof, that living animals possess a property of generating *cold;* on the contrary, they can only be esteemed as well-authenticated facts, showing that the matter of heat is not propagated through living bodies in a similar way as in inert matter of the same nature: and they afford a very forcible illustration in confirmation of Dr Cullen's opinion, in addition to many of the above-mentioned remarks, which evidently tend to the same conclusion.

The cause why animals who breathe have a permanent temperature, when exposed to a very low or a very high degree of heat, has been supposed, in a certain degree, owing to the general effects of that fluid upon the living system. Heat, in proportion to its degree of stimulant power, increases the circulation, and the perspiration of course becomes thereby more copious, both from the skin and pulmonary system; and the evaporation of this moisture must tend, in a very powerful manner, to keep the temperature nearly to the natural standard. Again, in animals of the same kind who resist the freezing effects of cold, it has been supposed, that the greater quantity of caloric that is set free by respiring a denser atmosphere, may to a certain degree compensate for the heat that is necessarily abstracted from the bodies of animals, by the low temperature of the surrounding medium; though, in opposition to this opinion, it must be observed, that Ingenhouz found, that in the same situation, the air is not so much vitiated by respiration in cold weather or during winter, as in warm summer weather, the difference being in the proportion of four to five; and Spallanzani has ascertained the same fact in regard to the changes induced upon the atmosphere by snails, and some of the warm-blooded dormant animals.—See Memoirs on Respiration, *passim*. These observations seem unfavourable to the beautiful hypothesis Dr Crawford promulgated in explanation of the above circumstances, and which, he supposes, was completely established by some experiments he conducted to ascertain more completely the power which animals possess of generating cold. He found blood taken from the jugular vein of a dog, whose heat was raised to 109°, by plunging him in water at 114°, that instead of the darker colour peculiar to venous blood in a natural state, it had become florid, and in every respect similar in its appearance to that of the arteries. And, although this appearance was most remarkable in the venous blood of a dog, previously weakened by blood-letting, yet the same thing took place in every one, but in a more gradual manner. He also ascertained by experiment, that venous blood became darker than common when the animal was confined in a cold medium.

Dr Crawford endeavours to explain these appearances, by adverting to the cold produced by the increased evaporation of the lungs, when an animal is exposed to a great heat. From the same cause, that power, by which the blood in its natural state is impregnated with phlogiston, is thereby diminished; on the contrary, it is increased by the animal being exposed to a cold temperature of the air: he likewise takes it for granted, that he has demonstrated the superior capacity of arterial blood for caloric; that this capacity is augmented in the lungs, and its temperature supported by caloric, separated from the air in respiration, otherwise it must sink 30°. Hence, if the evaporation from the lungs be so much increased, as to carry off the whole of the heat arising from this source, the arterial blood, in returning by the pulmonary veins, will have its sensible heat greatly diminished, and will consequently absorb heat from the adjacent parts, which it will give out in the minute vessels; and, in this manner, the temperature of the whole system is lessened, when exposed to an high temperature.—See Phil. Trans. 1781, part ii. p. 487. But, from what has been shown, the principles on which this hypothesis is established are fallacious, and of course it does not claim farther refutation: but, even according to Dr Crawford's own experiments, the heat of the system does actually suffer an augmentation, according to the temperature of the surrounding medium. A dog, whose heat was 102°, on being immersed in water at 114°, had his temperature increased to 108° in the course of eleven minutes, the water having sunk to 112° in the same time. Although the temperature of the system must be regulated, in a great degree, at all times, according to the quantity of the cuticular and pulmonary discharge; yet, from the facts afforded us by Ingenhouz and Spallanzani, we presume, that the red colour of the venous blood, in the circumstances observed by Dr Crawford, must have arisen from the superabundant absorption of oxygen from the air, in consequence of the high temperature;

a greater proportion being absorbed in these circumstances, than what is wanted for the purposes of the system ; consequently a considerable portion of the oxygen will pass unchanged with the blood from the arteries into the veins, and thus occasion the particular appearances that have been remarked in venous blood. On the contrary, in a cold state of the air, less oxygen gas being absorbed, the colour of the venous blood will be darker, in consequence of the more partial excretion of carbonic acid, there being an insufficiency of oxygen present to produce its complete evolution.

In conclusion, although the heat which an animal is supposed to receive by respiration, is solely that which is combined with the atmosphere in a latent state ; nevertheless, the proportion of that fluid which is united with it in a sensible and free state, will likewise be occasionally communicated in the same manner, but differing in degree, as when an inert mass of similar matter is exposed to its influence. It seems entirely owing to the peculiar affinity, subsisting between the matter of heat and bodies possessed of the living principle, that the permanency of their temperatures is to be ascribed ; at least this seems to take place in those instances, where a decomposition of the atmosphere by respiration does not occur. Upon the whole, it does not appear, that the quantity of caloric which can possibly be communicated to the body by a decomposition of the atmosphere by respiration or otherwise, especially on reflecting on the circumstances in the extrication of that fluid, is sufficient to account for the variations of the temperatures of living bodies.

SECT. III.

OF THE INFLUENCE OF THE ATMOSPHERE ON GROWING PLANTS.

Although vegetables do not seem to effect those changes in the composition of the atmosphere, which we have seen are produced by animals in the performance of their functions; nevertheless, we shall find, by an attentive examination of their economy, that the access of the atmosphere is no less necessary in the growth of plants, than it is for the continuance of animal life: and, like animals, plants are also found to die when confined within a vacuum, or in any of the irrespirable gases. The peculiar influence of the atmosphere on growing plants, is equally essential at every period of their existence; the same in the germination of seeds, as after the complete evolution of their organs. The following observations will be therefore more easily comprehended, by attempting to trace the influence of the atmosphere upon living plants during every period of their growth, commencing with its effects in the process of germination.

Every kind of vegetable is originally raised from seed, whose general structure is probably similar in every species, however they may vary in figure, size, or consistence. The structure of seeds is most distinctly seen in such as are bilobular; and the parts become more apparent, by previously soaking them in water for a short time. Next to that part of the seed which had fixed it to the plant, as the eye in every kind of pulse or grain, a small white body is to be discerned between the lobes, of a round form, and distinct from their substance. This organ is called the radicle of the seed, from the purposes it serves in penetrating the soil, and in forming the root of the young plant. Opposite to the place which the radicle occupies in the seed, there is another body, apparently similar to it in every respect, which is named plumula: this is the particular portion of the seed which tends upward through the soil; and from it the peculiar distinctive characters of the plant are produced, as the stem, branches, leaves, flowers, and fruit. By the evolution of these two organs, the plant is fixed in the ground, and acquires the necessary structure for reproduction.

During germination, the plumula and radicle draw the greatest part, if not the whole of their nourishment, from the farinaceous matter of which the cotyledons are composed. This seems evident, from the ramifications of vessels being perceived issuing from these organs, and passing through the substance of the lobes of a germinating seed; and by finding, that a considerable alteration in the quantity and properties of this farinaceous matter takes place in this process. As the seed becomes fixed in the soil, by an elongation of its radicle during germination, it is at the same time perceived, that the plumula makes a proportionate progress upwards, and that, towards the termination of this process, the lobes likewise ascend to the surface, gradually changing their appearance; and by the time they have completely penetrated the soil, they seem to have acquired the colour and other general properties of leaves. In this state, they are called seminal leaves; and although they are merely temporary, and only remain till the stem acquires a certain degree of length and firmness, and till at least two other leaves begin to shoot from it, nevertheless, if at this period they happen to be destroyed, or are intentionally taken off, the farther growth of the plant immediately stops, and it frequently begins to decay,—a circumstance which affords a certain proof, that, at this stage of vegetation, the functions of the seminal leaves are of the highest importance in preparing nutriment to the other parts of the plant. When nothing interferes to prevent the progress of vegetation, the plant gradually acquires solidity and length in its stem ; it puts forth branches, leaves, and flowers, which complete its perfect figure.

As soon as the seminal leaves have reached the surface of the soil, and are freely exposed to the open air, the plant then commences a new series of functions, different from those it performed in its embryo or germinating state. These we shall now proceed to consider, in as full a manner as the limits of this work will permit; but especially confining our observations to the influence of the atmosphere in the functions of the vegetable economy.

Of Germination.

At an early period of the investigation of this process, it was ascertained by Boyle, Ray, Muschenbroeck, and others, that the germinating property of seeds may be preserved for a considerable length of time, even when the atmosphere has no access to them, as in the exhausted receiver of an air-pump, and when every other circumstance is favourable for the commencement of their germination.

M. Achard has likewise ascertained, that seeds do not germinate when surrounded with the nitrogen or hydrogen gases; and Scheele, Priestley, and Sennebier, have shown, by very decisive experiments, that germination commences more vigorously when seeds are confined in oxygen gas, than when the aërial surrounding medium consists of atmospherical air. It has likewise been determined, by repeated experiments conducted by the most celebrated philosophers of modern times, that seeds steeped in a quantity of oxymuriatic acid previously to being sown, germinate earlier than others not so treated. From these experiments, it has been concluded, that the oxygen gas of the atmosphere is more essential than its other component parts in the commencement and for the continuance of the process of germination : and by Sennebier and many others it has been confirmed, that seeds do not germinate without the presence of oxygen gas. Saussure has shown, that while seeds continue to germinate, they emit a considerable proportion of carbonic acid gas; that this gas is always evolved in proportion to the quantity of oxygen gas absorbed, and, consequently, the oxygen gas is not diminished in quantity in its combination with the carbon of the seed. The same ingenious philosopher has likewise found, that carbonic acid is itself an obstacle to germination, when mixed in the atmosphere beyond its natural proportion ; and that it is then more pernicious than if the air contained an equal volume of nitrogen or hydrogen gases. He likewise perceived, that the solution of carbonic acid gas in water has an equally baneful effect. From a series of very accurately-conducted experiments, M. Saussure concludes, 1st, That the oxygen gas of the air is absorbed during the process of germination, not by the seeds, as seems to have been hitherto admitted, but is employed merely in forming the carbonic acid with the carbon of the new seeds; 2dly, The germinating seeds, when in contact with the air, do not form carbonic acid from their own substance, but only furnish a component part of it, viz. carbon. They yield, however, from their own substance, the oxygen and carbon of the carbonic acid formed when they are in contact with water, and pure azotic gas.

It must, however, be observed, that the power of oxygen gas or atmospheric air is not alone sufficient for the commencement, or even in most instances for the continuation of the germination of seeds, without the aid of other causes: thus, a proportion of water is no less necessary, together with a certain degree of temperature in the surrounding medium; nevertheless, it has been found, not only that light is not essential, but, from several experiments, it seems to have a hurtful effect in this process.

The Abbé Bartholon supposes this circumstance is entirely owing to the increased evaporation of water from the seeds, when they are freely exposed to the action of the solar rays. But, in opposition to this opinion, Sennebier has brought forward several very decisive experiments: he made seeds germinate in the sun and in the shade, taking every precaution to preserve them equal in point of humidity and temperature; and the uniform result of these experiments has shown, that seeds vegetate most vigorously in the dark. By this fact, we are enabled to comprehend the utility of the practice of harrowing sown ground, but which ought only to be to such a depth, as will not exclude the free access of the atmosphere, and will afford room for the elongation of the plumula. When treating of the properties of light, the influence of that fluid was pointed out in causing an extrication of oxygen gas from substances exposed to its power; and it is probably in this way we should explain the effect of light in the process of germination. By causing the evolution of oxygen gas from the germinating seed, it must prevent in a proportionate degree the generation of the saccharine matter, which we shall afterwards find is the most essential principle in the nourishment of the vegetable rudiment.

When seeds are exposed to a due degree of humidity, and are placed in circumstances where the atmosphere has free access to them, at a moderate temperature, they begin to swell, oxygen gas is absorbed from the air, carbonic acid gas is evolved, and a considerable increase of the temperature takes place in them; at the same time, the plumula begins to penetrate the husk. In this state, seeds are said to be *malted*; and on examining their properties, they are found to contain a quantity of saccharine matter, that did not previously exist in their composition, the whole of the farinaceous substance of which they are originally composed having disappeared. This change in the properties of the matter composing the seeds, is supposed to be effected by a diminution of their natural proportion of carbon, by the formation of carbonic acid gas, in the manner already pointed out, and a consequent proportional increase of hydrogen and oxygen, constituting the saccharine principle.

It is by the evolution of a process in a certain degree similar to germination, that old hay tastes sweeter, and is perhaps more nutritive, than what is newly gathered. And, on the same principle, we understand, how corns that are gathered and stacked during damp weather are so apt to germinate; and likewise, why hay heaped in these circumstances frequently heats, and even takes fire, by a more complete evolution of these changes; the increase of temperature in the germinating process rising in proportion to the changes that take place in the properties of the plant, and in the air with which it is surrounded.

This occurrence is easily prevented, by strewing a small quantity of common salt between every layer of the vegetable, in stacking it. In consequence of the strong affinity that subsists between the muriate of soda and water, it is thereby attracted from the damp vegetable, and tends to prevent its decomposition, and the consequent union of its principles with the matters which enter into the composition of the vegetable. By this practice, a provender is prepared more agreeable to cattle, than the plant in its natural state.

Having ascertained, that a certain degree of temperature, water, and the presence of oxygen gas, are essentially necessary for commencing germination, and for the continuance of this process; we shall endeavour to give an outline of the view that has been taken of the changes produced in the substance of the seed, by the action of these matters. It has been already shown, that germinating seeds emit carbonic acid gas, in consequence of the combination of the oxygen gas of the atmosphere with the carbon of the seeds; but this process never takes place, unless the seeds have been previously moistened with water, or some other liquid of which water forms the greatest proportion. It seems therefore probable, that some alteration in the principles of the seed takes place, in consequence of the action of water, before any portion of carbonic acid is evolved. This is evidently the case, from what has been observed by Carradori and others, that germination may commence when oxygen gas is not present, but that this process does not proceed without it,—a circumstance which affords a presumption, that the oxygen of the water supplies the place of that portion of this fluid contained in the atmosphere in the first stage of germination; the hydrogen being combined in the substance of the seed, to aid in the formation of the new vegetable products. A portion of oxygen gas, supplied from the decomposition of the air and water, is supposed to unite with the carbon of the farina, with which it forms carbonic acid; while another portion of the oxygen gas, with the hydrogen of the water, combine with the substance of the seed itself, thereby converting it into a substance of the nature of sugar.

Barley, and every sort of grain or fruit employed in distillation, as in making beer, wine, cyder, &c. must be brought to this state of malt, or contain naturally a proportion of sugar, otherwise these products cannot be obtained; it being entirely owing to the decomposition of saccharine matter, and to some peculiarity of the other vegetable principles, with which this substance is combined, that constitutes a difference in the strength and flavour of all fermented liquors. It therefore follows, that grain not previously malted, when mixed with a certain proportion of malt, can add nothing to its qualities for the purpose of distilling vinous liquor. In such cases, the quantity of wash or matter to be distilled, may be thereby increased, and consequently the volume of the distilled liquor; but in every such instance, it must be with a diminution of the quality and strength of the product, as it will necessarily be mixed with many foreign substances, arising from the extract of the raw grain.

Having in this manner given an outline of the theory of germination, we shall next proceed to investigate the changes produced on the principles of the atmosphere, by vegetables in their mature state, constituting that which has more particularly acquired the name of vegetation.

Of Vegetation.

In every plant there is a common mass of humour, called the Sap, from which the different organs of the vegetable economy are supplied with nourishment, in this respect answering the same purposes as the mass of blood in the animal system; and in like manner it is conveyed to every part of the plant by means of vessels, from which the peculiar secretions of the organs are formed. Vegetables are supposed to receive nourishment by their roots, which is carried forward by vessels passing through them towards the trunk and branches; these contain the common fluid above mentioned. But besides these sets of vessels, there are supposed to be others also, which take their rise from the under surfaces of the leaves, for the purpose of conveying down to the interior of the trunk the particular fluids which they have the power of imbibing from the atmosphere. Changes are likewise effected on this medium, by the outer surfaces of the leaves, not only by emitting excrementitious effluvia, but by absorbing fluids from it of the first importance in the vegetable economy. In these respects they have been supposed to perform some similar function in the vegetable system, to what is effected by the lungs in animals.

For a considerable time after the celebrated experiment of Van Helmont was made known, it continued to be the general opinion, that water supplied every thing that is necessary for the nourishment and growth of plants; this philosopher having found, by an experiment conducted with seeming accuracy, that a willow kept growing in a pot, the upper part of which was covered with a leaden plate, having a hole to admit the stem of the plant to pass through, and which had been only supplied with water, continued to grow, and had acquired a considerable addition of weight in the course of five years. This opinion was supposed to have been confirmed by what is daily perceived to take place in the growth of hyacinths, mint, and a variety of flowering plants, which vegetate freely in jars containing water only. Mr Boyle, Duhamel, Tillet, and Bonnet, conducted many similar experiments; and the general result of the whole, is the same as in that of Van Helmont: the plants had not only acquired a considerable addition in their fluids and softer parts, but likewise in the solid ligneous fibre,—a substance which does not appear could be formed by the decomposition of pure water alone. This circumstance was satisfactorily accounted for afterwards, on finding that an absorption of every matter that is usually found in the composition of vegetables, might have taken place from the soil, through the substance of the pots in which the plants grew, and from the surrounding atmosphere, which, together with the proportion of earthy and other matters naturally contained in water, were sufficient to account for the growth of the plant submitted to experiment. This opinion seemed to be confirmed, by having ascertained that plants reared in this way afforded similar component parts, as others of the same kind, which had been allowed to grow in the soil in which the pots were placed. Were it not in consequence of these circumstances having taken place, Bonnet could not have affirmed, that the odorous principle of plants fed with water solely, was always stronger than in those raised from the soil in the open air, or that the fruit was uniformly of higher flavour. In M. Hassenfratz' first memoir on Vegetation, in the

13th volume of the Annales de Chimie, he points out very clearly, circumstances which prove, that the plants used in the experiments of Duhamel and Tillet must have imbibed their component matters from the soil. Tillet's experiments were conducted in unglased pots, which were kept standing in vegetable soil during the whole period of the experiment. And, accordingly, on repeating these experiments, Hassenfratz found, that the pores of the pots acted in the manner of capillaries, extracting nourishment from the soil in dry weather, and affording an outlet for the superabundant moisture when the weather is rainy. This philosopher never could get plants, raised by a supply of water alone, to ripen their seeds, although they commonly put forth flowers.

It has been shown by similar experiments performed by Saussure, that plants raised by means of pure water, in an atmosphere from which the carbonic acid gas was extracted, always lost by drying the weight they had acquired during the experiment; while, on the other hand, when vegetation was promoted by allowing the carbonic acid gas to remain in the surrounding medium, the weight of the plant far exceeded the weight of the carbon lost by its decomposition. M. Hassenfratz likewise found, that the component parts of plants reared by water alone, are very different from the proportions obtained from similar plants which grew in the soil, exposed freely to the open air. And by analyzing several varieties of plants which were made to grow in distilled water, he found, that the proportion of carbon they contained was less than what had entered into the original composition of the seeds or bulbs from which they had sprung.

In confirmation of the accuracy of these experiments, it has been ascertained, that matters enter into the general composition of vegetables, which can only be procured from the soil in which they grow : some of the earths, as lime, silex, or flint, several of the salts, some simple, others of a compound nature, as potash, soda, phosphate of lime, nitrate of potash, muriate of soda, and even some of the metals, have been said to have been discovered in the constituent principles of vegetables. We have also another evident proof, that water alone does not afford the only principle of nutriment for vegetables; for were this really the case, the exhaustion of the soil by the continued succession of the same crop, would have never occurred, as it must have answered every requisite purpose, while it retained a sufficient degree of moisture and of consistence to afford support to the roots of the plants. This idea was perhaps first entertained by Dr Woodward, towards the end of the seventeenth century; he having remarked, that were water the only nutrient principle of vegetables, a succession of different crops on the same land would be unnecessary,—an observation which equally applies to any doctrine that assigns the nourishment of plants in general to the absorption of one particular matter. From the analysis we have already stated, as constituting some of the component principles of vegetables, it seems probable, that different matters are suited as nourishment for different plants, and probably for the same plant at different periods of its growth. Thus humidity seems most essential for young plants, and for such as produce succulent fruits: it is probably in consequence of this circumstance, that drought in the beginning of summer is commonly followed by such bad consequences in this country; and it explains also, why the soil is less impoverished by crops of plants which require a greater proportion of water for their nourishment. Again, carbon and saline matters are perhaps most essential for the maturation of fruits, especially such as are dry and mealy: hence we have one reason why a rainy summer and autumn are unfavourable to the ripening of all sorts of vegetable produce.

Having ascertained that water, carbon, earthy and saline substances, are the matters contained in the soil most essential for the growth of plants, and that different proportions of these are required by different species of vegetables, by a previous examination of the soil, in order to acquire a knowledge of these proportions, we are in this manner enabled to select the proper situation for various kinds of vegetable productions. As the soil not only affords support to the plant, but likewise contains matters necessary for its nourishment; for these reasons, it must be reduced to a state that will allow the roots to spread easily through it, and to penetrate the necessary depth, not only to secure the plant, but that it may reach those situations, where matters fitted for its nourishment most copiously abound. It is with this intention that tillage, and the various other methods of labouring the soil, are had recourse to in the practice of agriculture. Soils are commonly composed of the four following earths: alumina or clay, silex, flint or sand, lime, and frequently magnesia, and with the remains of vegetable and animal matters, which chiefly consist of carbon and saline matters, mixed frequently with a proportion of the carbonate of iron, to which the peculiar brown colour of certain soils is entirely owing. The soil, so far as depends on the different earths composing it, when divided into eight parts, ought to consist of three parts of clay, three of chalk, with two of silex; this last is in general in the form of sand: magnesia rarely forms a remarkable proportion of the soil. Soils are distinguished by different denominations, according as either of these earths most abounds. A fertile soil has therefore its ingredients mixed in such proportion, that while it is sufficiently porous to allow superfluous water to drain off, it is still of sufficient firmness to give stability to the plant, and to retain the necessary degree of humidity for its growth.

It is by the judicious application of any of the above-mentioned substances, that the agriculturist has it in his power to alter the properties of particular soils. To a sandy soil he adds clay and a little lime; with a clay soil he mixes the necessary proportion of the other earths, thereby rendering it more porous, and which, with the assistance of drains, will likewise render it more dry. M. Hassenfratz has related the particulars of several ingenious experiments in the 14th vol. Annales de Chimie, by which he has ascertained, that manures are beneficial in the growth of vegetables, in proportion to their state of putrefaction. When the putrefaction of manure has reached its utmost extent, their effects were almost immediate; while other manures produced an influence gradually as their component matters decayed. Thus, a small piece of land spread over with a mass of dung and straw, in a highly putrid state, raised a much better crop, than that which grew upon an equal extent of soil, which had been manured with dung and fresh straw; but, during the two following years, the crops produced by the latter exceeded those raised from the former in a considerable degree. The same ingenious philosopher manured a small piece of ground with some chips of wood he had allowed to begin to putrefy, by keeping them continually moist in the corner of a court, from eight to ten months. For the first two years this seemed to have no effect in improving or in lessening its productive qualities: the third year the crop was better, and it gradually improved till the fifth year, when it seemed to have reached its maximum: its fertility gradually declined till the ninth year, when its effects seemed to be entirely exhausted. By these experiments, the importance of manure in the growth of vegetables has been demonstrated in the most decided manner; and the way in which these experiments have been conducted, affords, in other respects, a most interesting practical lesson to the landholder, which is equally necessary for the consideration of the cultivator: to the former it holds out, in a very palpable manner, the advantages which can alone accrue by granting leases of a considerable number of years duration; and they may serve to guide the occupier of the ground with respect to the propriety of undertaking certain processes at different periods of his lease. But although farm-yard manure has been generally found highly beneficial in promoting vegetation, Duhamel has ascertained, that when it is applied in superabundant proportion, it operates as a poison, certain vegetables refusing to grow in it, and others do not arrive at a proper state of maturity. It has been supposed, that in a fertile soil the carbon does not exceed one-fifteenth of the mass: the proportion of saline matters have not been estimated. In what manner the roots attract nourishment from the soil, and propel it forward through the trunk and branches, and how the different vegetable matters are formed from these, have not been hitherto ascertained.

Ingenhouz was perhaps the first who ascertained, that the soil fresh turned up, absorbs oxygen gas from the air. At the same time, a quantity of carbonic acid is emitted in consequence of its union with the carbon of organised matters in a state of decay. It is very doubtful, however, if oxygen be absorbed by the roots of plants from this source; it seems more probable, that the appearance takes place in consequence of the strong affinity existing between the carbon of the soil and the oxygen of the air, by which an union is formed between minute portions of these matters. The effect of manures in promoting vegetation has been supposed to be in a great measure owing to the quantity of saline, but, especially of the carbonaceous matters with which they abound; other substances of which this forms the principal ingredient, having been found to answer the same purpose in the most perfect manner. Besides, we have every reason to consider carbon, in some particular state or other, is copiously employed in the vegetable economy, by finding, in the analysis of plants, that it forms the principal ingredient in their composition. What the particular condition of carbon is, which renders it fit for vegetable absorption, is not yet known: it seems probable, however, that it is such as it exists in the liquids draining from dung heaps. It would appear from the experiments of M. Hassenfratz, contained in his second Memoir on Vegetation, in the 13th vol. of the Annales de Chimie, that plants grow most vigorous in places where the carbon, in a state of solution, is most abundant. In his third Memoir on Vegetation, he adduces the experiments of Baisse and Bonnet, in proof that plants draw their nourishment principally by their roots. The experiments of the former gentleman were read before the society at Bourdeaux, and shew that plants growing in water tinged with madder, acquired a reddish tint in their leaves. In Bonnet's experiments, ink was the medium employed, which in like manner tinged the surface of the plant of a dark colour. From what we have premised on the matters fitted for the nourishment of vegetables, it will be perceived, that from water, soil, and manures, plants draw the whole of the nutritious matters absorbed by their roots.

Saussure has shown, that roots absorb salts and vegetable extract from the soil, but always in it, and others do not arrive at a proper state of maturity. It has been supposed, that in a fertile soil the carbon does not exceed one-fifteenth of the mass: the proportion of saline matters have not been estimated. In what manner the roots attract nourishment from the soil, and propel it forward through the trunk and branches, and how the different vegetable matters are formed from these, have not been hitherto ascertained.

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Saussure has shown, that roots absorb salts and vegetable extract from the soil, but always in less proportion than when these matters are held in solution by water. The salts commonly found in plants, seem to have suffered no change in being submitted to the powers of the vegetable functions. The same ingenious author discovered phosphates uniformly by the incineration of vegetables: these were commonly the phosphates of lime, sometimes the phosphate of potash, and not unfrequently a combination of those salts. Marine plants contain soda; other vegetables afford compounds of potassa by their decomposition.

But although these are the general principles which afford nourishment for vegetables, it does not follow, that every variety of plant absorbs a proportion of each of them; on the contrary, it seems probable, that different kinds of plants require different matters for their nutrition. It is owing to this circumstance, that different districts are better adapted than others for raising certain grains and fruit, and that particular crops are found to be most abundant when sown in succession.

In consequence of some experiments conducted by Dr Priestley and others, at an early period of pneumatic chemistry, it was supposed, that plants grew and flourished in air that had been contaminated by the respiration of animals, or which had been altered by matters in a state of combustion. Sennebier found, that plants vegetated more luxuriously when watered with a saturated solution of carbonic acid and water: by the experiments of Ingenhousz and Saussure, it would likewise appear, that carbonic acid gas is absorbed from the atmosphere by growing plants, whose growth is thereby greatly quickened. However, Mr Scheele did not find by his experiments, that carbonic acid gas is altered by the effects of vegetation: these trials are related in his Opuscula Chemica et Physica, and afford the most decisive arguments against the former opinion. M. Hassenfratz conducted several experiments, which, in their result, coincide with those of Scheele. He could not perceive, that at the end of two months, his plants had increased or diminished the quantity of carbonic acid gas in the air surrounding them, and this uniformly happened, even when every precaution was taken to prevent errors which might arise from the emission of any thing from the earth, in the pots in which the plants were set to vegetate. From this circumstance he infers, that the decomposition of carbonic acid gas by plants in the process of vegetation, on the presumption of their absorbing its carbon, is thus completely invalidated. M. Hassenfratz likewise supposes, that the experiments of Sennebier and Ingenhousz on this question admit of a different explanation than what they have inferred from them. He imagines, that by the influence of the solar rays, plants discharge oxygen gas by their leaves, which they again absorb during the absence of the sun, and which, uniting with part of the carbon of the plant, is again evolved in the composition of carbonic acid gas, which is communicated to the atmosphere, along with the watery vapour. From these circumstances he concludes, that it is not from the carbonic acid of the atmosphere, that vegetables acquire their increase of carbon: this, according to the explanation he offers in his third Memoir on Vegetation, 14th vol. of the Annales de Chimie, arises from the carbon which plants take up by their roots from the soil in which they grow.

Although there is not a doubt, that carbonic acid gas is unfavourable to the germinating or malting process of seeds, and even to vegetables in their mature state, if it solely or in greatest part composes the surrounding medium, yet from the repeated experiments related by Dr Percival and others, it would appear, that when plants are supplied with this gas in a moderate proportion, and along with oxygen gas or atmospheric air, that it is of the most essential advantages in their growth.

Saussure *junior* found, that air freed of carbonic acid gas supports vegetation in the sun's rays; but if quick lime, a caustic alkali, or any substance that rapidly absorbs carbonic acid gas, be placed in the receiver where the plant is confined, it will soon perish, and this takes place whether the plant be made to grow in earth, or in water. But when the plant is placed in the shade, the lime becomes useful by absorbing carbonic acid, as in that circumstance this fluid has an hurtful effect in vegetation. He likewise finds, that air containing $\frac{1}{12}$ carbonic acid gas, is favourable to vegetation, but that a greater proportion of this fluid in the surrounding medium has the most pernicious effects. The same philosopher likewise found, that plants which were made to grow in distilled water, and surrounded with air deprived of its carbonic acid gas, made no acquisition of carbon. From these experiments, it may therefore be concluded, that plants have the power of imbibing carbonic acid gas from the atmosphere.

There are many experiments which tend to prove, that carbonic acid gas is principally absorbed by plants in the day time; it having been found, that during night, the leaves perform functions in some degree different, by attracting aqueous vapour from the air,—a circumstance which is confirmed by finding, that plants are always heavier in the mornings, and that their weight is considerably increased by the precipitation of moisture from the atmosphere. And it seems to be in consequence of this power in vegetables of decomposing the atmosphere, and of absorbing the aqueous vapour it contains, that several species of plants flourish in the most arid and rocky situations. As a further proof of the absorption of the carbonic acid gas from the atmosphere by the leaves of plants, the observations of Chaptal on this subject may be adduced. He found, that fungi which grew on subterraneous places are almost totally resolved into carbonic acid; but if they be gradually exposed to the light, the proportion of acid diminishes, while they acquire an increase of the carbonaceous principle.

Ingenhousz perceived, that when a plant is confined within a certain portion of air, that its quantity diminishes, the oxygen gas almost wholly disappears, while the azotic part of it remains nearly entire; these observations have been confirmed by repeated experiments by others. Nevertheless, M. Hassenfratz, as well as Saussure *junior*, have found, that the air surrounding green peas, and young chesnuts, also was not altered in its properties thereby. This exception seems readily to admit of explanation, from our acquaintance with certain functions of vegetables, which will be afterwards mentioned; by which the leaves perform different offices during day, from those they discharge in the night. And from their resemblance to certain functions in the animal system, they have been denominated respiration, and transpiration; the fluids emitted in the day time, being in every respect similar to those which are absorbed during night, and *vice versa*: in this way, perhaps the quantities of those fluids submitted to the action of organs so opposite in their natures, will, in some instances, nearly compensate each other; and this was most probably the case in the experiments above mentioned, they having been continued for the space of ten days.

Besides the absorption of the oxygen gas of the atmosphere by the leaves of plants, it would appear that a portion of the azotic part is also taken up by the same organs; this is inferred from some early experiments of Dr Priestley and of Sennebier: it having been found, that plants continue to grow for some time when surrounded by this gas, and that it suffers even a diminution of its quantity. Besides the proportion of nitrogen gas absorbed from the air in this manner, a considerable quantity of this gas is constantly applied to the roots of plants, in the decaying remains of animal substances of which manure and the soil contain a considerable proportion; for these reasons it is naturally inferred, that nitrogen gas serves an important purpose in the functions of vegetables. M. de Saussure concludes, from many ingenious experiments which he performed with a view to determine the changes produced on atmospheric air by growing vegetables, that carbonic acid gas is imbibed by the leaves in the day-time, but at night, or in the shade, oxygen gas, with a small portion of azote and watery vapour, are taken up by them. However, Mr Scheele has found, that by confining peas in a jar containing oxygen gas, while they remained about half covered with water, the oxygen was in every instance converted by them into carbonic acid, in the same manner as in animal respiration. The experiment is related in the following words, in the 1st volume of his Opuscula, page 110, "Cucurbitulæ ad xx. aquæ uncias capaci pisa aliquot indidi, aqua superfusa, quæ pisorum medium contegeret, vasque occlusum. Pisa radices egerunt, et excreverunt; diebus quatuordecim præteritis, qui ista non altius surgere cernavi, cucurbitam inversam sub aqua aperii. Aër nec auctus nec imminutus visus, quartum ejus partem calcis lac hausit, cæterum flammam necavit.—Cucurbitæ radices recentes fructus, herbas, flores, folia, singula sola clausi; item aliquot diebus post quarta aëris pars in acidum aëreum se verterat. Is ipse aër muscis repertinam necem attulit."

Dr Darwin proposes a theory respecting the changes produced on the atmosphere by living vegetables, which seemingly affords a true explanation of their functions: he supposes, that in the function of the leaves, analogous to the respiration of animals, carbonic acid gas is always emitted in every situation; on the contrary, it is by transpiration alone, that vegetables emit oxygen gas, and only when they are exposed to the action of the solar rays, and which solely arises from the decomposition of water in the organs of the plant. Mr Scheele has shown, that oxygen is emitted by the leaves of plants, when they are surrounded by pure nitrogen gas. And Sennebier has likewise ascertained, that by exposing plants to the influence of light, when surrounded with nitrogen gas, in a short time it becomes as pure as common air, evidently in consequence of the emission of oxygen gas by the leaves of the plant,—a fact which we therefore consider as fully determined.

Water taken from springs or rivers, but especially rain-water, always contains a quantity of oxygen gas. M. Achard has likewise discovered a considerable portion of this gas in snow. It seems therefore very probable, that it is chiefly owing to its effects, that snow-water or showers of rain manifest the most beneficial influence in promoting vegetation; plants entering into union with it, by separating it from the water, which they absorb. A certain degree of temperature, and the influence of light, are not less necessary for carrying on vegetation. Sennebier found, that plants which grew in the dark, contained a less proportion of hydrogen and of oleaginous matter, than the same kind of plants which had been raised in the open air; their resinous principle being in proportion to that of the latter, as 2 to 5.5: the other vegetable principles were in general about one-half less, and they contained a double proportion of water.

This philosopher gives an account of some experiments in his Physical and Chemical Tracts, which illustrate the power of different coloured rays in promoting vegetation,—see page 59. 3d volume. Having put some lettuce seeds, to grow, in bottles of different coloured glass, he perceived, that at the end of six weeks they had increased four inches and nine lines in the red coloured bottle, three inches and three lines under the violet coloured bottle, two inches ten lines under the bottle filled with plain water, and one inch three lines in the open air.

Dr Priestley had discovered about thirty years ago, that plants immersed in water, and exposed to the sun, give out a considerable portion of oxygen gas: and the accuracy of this observation has been confirmed by the result of several experiments performed by Ingenhousz and others. This gas is principally, if not wholly, emitted by the under surfaces of the leaves of trees in such experiments. The oxygen emitted by young leaves, is much smaller than those which are full grown, and the quantity is generally proportionate to the greenness of their colour; yellow, red, or dried leaves, scarce afford any of it. And in the 3d volume of Sennebier's Experiences Physico Chymique, he there shows, that neither seminal leaves, nor the leaves of plants that are etiolated, give out oxygen gas in any circumstances. Oxygen gas is even emitted by fresh leaves cut in pieces, and they emit it without being put into water.

But Sennebier has shown, that the extrication of oxygen gas from plants immersed in water, only takes place when the water contains a quantity of common air; having found, that water, from which the air had been expelled, did not afford this gas,—a circumstance which, however, was originally pointed out by Dr Priestley. Sennebier has also shown, that the quantity of oxygen gas emitted from plants immersed in water, bears always a proportion to the carbonic acid gas it contains, being often as 528 in experiments with water impregnated with this gas, to 2 when the leaves were plunged in water containing common air. This fact seems to add confirmation to the opinion already stated, that carbonic acid is copiously absorbed by vegetables, during the influence of the sun's rays; and that the oxygen gas evolved by them, at the same time, is in consequence of the decomposition of that gas in the system of the plant. The leaves of plants commonly emit a considerable quantity of watery vapour during day. Dr Hales was the person who first attentively examined this subject; he found, that a cabbage perspired daily a quantity of humidity nearly equal to half its own weight. The upper and under surfaces of leaves perform offices directly opposite in their nature to each other; the exhalations from the plant being generally discharged from the upper side, while, on the contrary, the atmosphere and vapour are supposed to be imbibed by the under side of the leaf. It is owing to this circumstance, that a leaf laid with its under surface upon water, will remain fresh for a considerable length of time; while, on the contrary, if the upper side be applied, it soon begins to wither and decay. This is the nature of the functions performed by the leaves of trees, shrubs, and of plants of a pure ligneous texture; at the same time it is to be observed, there are others of the herbaceous kind, whose leaves perform their functions in a manner the very reverse.

From the leaves of plants performing different functions during day from what takes place in them during night, and considering the affinity of light to the matters extricated; its influence and that of caloric in the functions of vegetables are shown in the most evident manner. The fluids which plants transpire are found, when collected, to putrefy quickly; and it has been ascertained by Dr Hales, and Duhamel also, to consist almost entirely of water and the aroma of the plant,—a fluid evidently partaking of peculiar properties, according to the nature of the plant from which it exhales. Carbonic acid gas is plentifully emitted by vegetables during night, and the quantity of this gas evolved is supposed to be in proportion to the quantity of oxygen absorbed, Ingenhousz having perceived, that it is most copiously emitted by vegetables confined in oxygen gas. Housy perceived, that carbonic acid gas is abundantly emitted by flowers, even when exposed to sunshine, and that, at all seasons, flowers and fruits perspire a quantity of nitrogen gas also.

It has been ascertained by Saussure, that the surfaces of the wood, and the petals of vegetables, do not absorb any thing from the atmosphere, but communicate carbon to the surrounding oxygen; and, at the same time, a quantity of water seems to be generated. He has likewise found, that fruits, whether they continue green or not, do absorb oxygen gas from the atmosphere, and produce a compound effect upon it. It has been likewise remarked, that the functions of leaves are exactly similar when light is excluded from them, even in the day-time; they then absorb oxygen gas from the atmosphere, which is again emitted on being exposed to the light. These, and the foregoing facts, bear further evidence of the importance of light in the process of vegetation; though the manner how its influence is exerted in this respect has not been ascertained; however, we have adduced the most conclusive proofs, tending to show, that it is an agent indispensably necessary in the vegetable economy, after the seed has matured its functions.

The functions of vegetables have been in this way so far ascertained. We find, that water, earthy and saline matters, with carbon, and perhaps azote, are taken up from the soil by their roots. The functions performed by the leaves seem to be in some respect analogous to the functions of respiration and perspiration in the animal system, oxygen being absorbed from the air, and carbonic acid gas given out. It seems also probable, from the experiments of the philosophers whom we have mentioned, that plants exposed to the sun's rays emit oxygen gas, along with a quantity of watery vapour; and it has been supposed, that in these circumstances carbonic acid is imbibed from the atmosphere. In the night season, aqueous vapour is imbibed by the leaves from the surrounding air; and, according to some experiments, oxygen and nitrogen gases also are taken up at the same time; and at this season, carbonic acid gas is evolved in greatest abundance. It has likewise been shown, that nitrogen gas is at all times extricated from flowers and fruits, and that they have the power of decomposing the atmosphere, by absorbing oxygen gas, and of consequently evolving carbonic acid gas, when exposed to the sun's rays.

Plants are supposed by some writers to grow faster during night than in the day-time: this circumstance is most remarkably perceived in the germination of seeds, and as the tender vegetable begins to penetrate the surface of the soil. Dr Darwin imagines this is the consequence of what is called sleep in plants; and, in this respect, he thinks they bear a striking analogy to what takes place in the growth of animals in early life. Nevertheless it appears to be owing, in an equal degree, to the stimulant effects of oxygen, accumulated in them during the absence of light, and the distention of the vessels, by the absorption of humidity from the atmosphere, which takes place during the absence of the sun's rays.

The green colour common to almost every variety of vegetable has been clearly traced to the action of light. This opinion was first assumed, from observing, that plants become etiolated or blanched, by earthing them up, so as to exclude the action of the sun's rays. There is likewise a considerable variety of roots which are naturally of a whitish colour, as potatoes, turnips, &c. and which suffer an alteration both in their colour and other sensible qualities, when exposed to the open air: hence, the green colour frequently perceived on a portion of a potatoe bulb, and the green variegated colour of turnips around where the stalk shoots out. The blanching of celery, asparagus, and the white inside leaves of cabbages, &c. are all in consequence of the action of the solar rays being precluded. That the green colour of vegetables is occasioned by the power of the sun's rays, is rendered still more evident, by finding, that when a plant is made to grow in the dark, the whole of its leaves and stalk also become entirely white or etiolated; and it regains its natural green colour, by being again exposed for some time to the united influence of the light and atmosphere. Mr Gough has found, that light does not perfect the green colour, without the co-operation of oxygen gas. M. Humboldt discovered some plants growing in the galleries of mines, where it is completely dark, but which nevertheless retained their natural green appearance. In such situations, the air is always found to be very damp; and it commonly contains a quantity of uncombined hydrogen gas; he therefore supposes, that the green colour of these vegetables may be owing to their having absorbed a quantity of this air. This opinion is rendered extremely probable, by finding, that it agrees with some observation of Ingenhousz on the same subject; this philosopher having perceived, that plants growing in hydrogen gas become more deep in their colour, than others of the same species growing in the open air. It may likewise be inferred from these facts, that it is in a great measure owing to the combination of this gas with plants growing in humid situations, as on the banks of rivers or lakes, that they are commonly perceived of a deeper green colour, than the same kinds of plants growing at a distance. According to this theory, the cause of the white colour of plants, in consequence of being deprived of the influence of the solar rays, must arise from the existence of a greater abundance of hydrogen and of oxygen gases in their composition, than what they contain when growing freely exposed to the sun and air,—an inference which is rendered still more probable, from what we have already premised on the effects of light, when treating of its properties.

The following is the theory of the changes which take place in growing plants, according to the opinion of M. Hassenfratz. Water is decomposed by vegetables, the oxygen being transmitted to the air in the form of gas, the hydrogen being retained as necessary in the functions of the plant for the formation of vegetable compounds. The carbonic acid, he supposes, originates from the absorption of oxygen gas from the air, thereby causing an union with the carbon of the plant. He supposes the temperature of plants is lessened by the decomposition of water in the plant, and the consequent extrication of oxygen gas, and the evaporation of a portion of the water imbibed by the roots. On the other hand, he imagines the temperature is increased by the formation of carbonic acid, as well as by the intimate combination of hydrogen gas with the other constituent principles of the plant. But, allowing this statement to be perfectly correct, it seems still doubtful whether the sources of temperature thus pointed out, are even sufficient for supplying the waste of caloric occasioned by the first-mentioned process.

In this way we have investigated the subject of vegetation, so far as it seems to depend on the influence of the atmosphere. The gases which plants absorb from it by their leaves, together with the matters taken up by their roots, after being elaborated by the functions which compose the vegetable economy, form all the varieties of vegetable productions; but in what manner these wonderful changes are perfected, remains still unknown.

By the facts we have had occasion to state, in our investigations of the influence of the atmosphere on the animal and vegetable functions, the remarkable dependence of these classes of beings upon each other, immediately presents itself to the mind in a very impressive manner. Our acquaintance with this connection, the offspring of modern improvements in science, like every other branch of knowledge, expands our ideas of the power and infinite wisdom of the beneficent Author of Nature.

Animals, by the extrication of carbonic acid gas, afford a fluid essential to vegetation. Plants, on the other hand, by the emission of oxygen, supply the atmosphere with oxygen gas, which is equally essential for the performance of the functions of the former class, and which has been supposed to bear an equal proportion to the quantity of that fluid which has been consumed by the exercise of their organs.

It may be proper to remark in this place, on concluding our observations of the effects of the atmosphere on living bodies, that oxygen gas seems to be set free in many other processes by the action of the sun's rays, where water is present in a certain proportion. It has been found that oxygen gas is evolved from water containing bits of rags, paper, glass, &c. when exposed to the sun's rays. The same effect is likewise most probably effected upon the dew and rain-water, occasionally adhering to the points and upper surfaces of the leaves of vegetables; this, with the nitrogen gas which arises from the decaying remains of animal matters, may not therefore be unjustly considered as the principal sources of the elementary gases of the atmosphere.

Some time after the foregoing pages were written, a work appeared by Mr Daniel Ellis, entitled, "An Inquiry into the Changes induced on Atmospheric Air, by the Germination of Seeds, the Vegetation of Plants, and the Respiration of Animals." In the perusal of this book we have received much pleasure; the doctrine it contains is related with much candour and perspicuity; the experiments are ingenious, and bear evident marks of being so far correct; and although we by no means embrace the opinions Mr Ellis has revived, he has evidently shown considerable merit by the manner he has treated these subjects.

In an investigation of the above inquiries, which are confessedly of the most interesting description, the grand aim of our labours is to draw up a correct theory from ascertained facts; we shall therefore add some farther observations, which either were omitted in our previous discussions on these subjects, or which have been suggested by the conclusions Mr Ellis supposes his experiments infer; and for this purpose, we premise a concise outline of his opinions.

Mr Ellis agrees, that at a certain temperature water and oxygen are absolutely necessary for continuing the functions of animals and plants; that a quantity of carbonic acid is thereby formed, in consequence of the extrication of carbon from the living system, which is always in proportion to the quantity of oxygen gas that disappears from the air. He supposes, that an absorption of oxygen gas does not take place in either of these classes of beings, in consequence of the decomposition of the atmosphere by their functions; nor does it find access in any other way to the fluids circulating in the vessels, by any affinity subsisting between their component parts and the oxygen of the atmosphere. The formation of carbonic acid, he thinks, takes place by the oxygen of the air combining with the carbon evolved by the leaves of plants, the spiracula of insects, the gills, the lungs, the skin, and alimentary canal of animals; that in each of the processes mentioned, the nitrogen gas of the atmosphere remains entire; and that in every instance these processes are followed by an increase of temperature. But in the performance of these functions it appears, by this examination, that the quantity of oxygen gas absorbed, exceeds considerably that which enters into the carbonic acid gas evolved. Mr Ellis likewise affirms, that plants have no power of excreting oxygen, but in consequence of the decomposition of water by means of the sun's rays; and that they only seem to act in this respect, the same as an equal volume of inert matter.

In our inquiries respecting the functions of respiration, and of the influence of the atmosphere on vegetation, we have already admitted the principle Mr Ellis has maintained, so far as the formation of carbonic acid depends on the disappearance of oxygen gas from the air by these functions; but, for the reasons we have formerly stated, we are still inclined to think, that the formation of carbonic acid does actually take place in the living system, and is generated in consequence of the commixtion of oxygen with the circulating fluids.

We certainly do not see any obvious inlet for the transmission of oxygen gas into the system; therefore it may be deemed unphilosophical, to presume that such a communication does actually exist. But it is no less certain, that the vessels which afford an outlet for the carbon or carbonic acid, are not more fully ascertained. But some analogous circumstances connected with anatomy, make us still inclined to suppose some way of communication between the circulating fluids in the leaves of plants, the lungs of animals, &c. and the air exposed to those organs, does exist. The orifices of the lymphatics are not visible in their natural state; yet every one is convinced of their existence, by the functions which are performed by them. To this fact, we shall only recall to recollection the dispute which was for a long time agitated respecting the existence of absorbents in the brain. The existence of such vessels in this organ was obstinately denied by anatomists, while others, better acquainted with the diseases by which it is occasionally affected, were convinced that it must be possessed of absorbent vessels, in common with every other organ of the body; and accordingly, within these twenty years, the actual existence of these vessels has been demonstrated. But what may appear to be a weighty objection to this theory in the opinion of many, and which Mr Ellis brings forward in support of his own ideas on the subject, is presumed from no person having ever detected any aërial fluid in the blood, and that even those the most salutary, when applied to the functions in a natural state, speedily bring on convulsions and death, when artificially communicated to the circulating mass. But although we see no reason to dispute the general truth of this experiment, there are others equally correct, which we have related, tending to show that aërial fluids do actually exist naturally in the blood, though in a more intimate union with that fluid, than what is presumed from that observation; and that even the aërial bodies existing in the blood, are different in masses of that fluid, taken from the veins or arteries. It is well known to every one familiar with the operations of the air-pump, that water and other liquids, though showing no appearance of containing air under the ordinary pressure of the atmosphere, yet are found to emit a considerable portion of such matters, when that pressure is removed. This is perhaps more remarkably shown in certain mineral waters, in such as consist of sulphuretted hydrogen gas in greatest quantities, or of carbonic acid gas: the taste of either of these is very distinctly perceptible, although the gaseous fluid is not visible in its union with the water, nor is it seen making its escape when a portion of it is poured into a glass. It is probably in a manner somewhat similar that the aërial fluids exist in the blood. But allowing Mr Ellis's opinion to be correct, that no portion of the atmosphere is absorbed, or otherwise communicated to the circulating fluids of animals and plants, in the above-mentioned processes, he does not adduce any proof that carbon is actually excreted from the system in the manner he supposes; nor does he show under what circumstances its union with oxygen takes place. The carbon which enters into the carbonic acid gas formed by the animal and vegetable functions, is evidently afforded by those bodies themselves; but if carbon in its simple state is evolved in this way, it is most probably the only instance of a simple substance being emitted from the system in an uncombined form. For this reason, we are inclined to doubt that such an occurrence ever takes place with the functions in a state of health.

Mr Ellis supposes the carbon is emitted with the aqueous fluid in respiration*; but we are not in possession of a single fact in support of this opinion; indeed, the appearance of pulmonary vapour militates against it: it is very well known, that carbon is completely insoluble in water; the dark-coloured liquor which drains from the manure in farm-yards, is by no means a proof of its solution taking place in any circumstances; the carbon in this instance being evidently suspended by means of other matters filtrating from the same mass. Besides, if pure carbon is really an excretion thrown off from animal and vegetable bodies when alive, along with a portion of aqueous exhalation, the purpose of its combination with oxygen, after the system has in this manner got rid of it, does not readily appear.

It has been already admitted, that the excretion of carbonic acid gas from the lungs, seems to be an important part of the function of respiration. But we have likewise endeavoured to show, that the absorption of oxygen gas from the atmosphere by that function, seems to be intended for the accomplishment of processes no less essential to the system: it most probably assists in the assimilation of the chyle, and in rendering matters no longer useful in the system more easily excreted: and even Mr Ellis's experiments appear to tend to this conclusion, as he admits that more oxygen disappears from the air in respiration, than what is necessary for the formation of the carbonic acid evolved. Several of the matters secreted by every other function, contain a portion of oxygen in their composition, and these seem to be most readily supplied with this gas by the function of respiration. We therefore do not agree with Mr Ellis, that the whole oxygen which disappears by the above-mentioned processes, enters into the formation of carbonic acid, or that this superabundance is accounted for, by the difference of its density in a free, and in a combined state; the excess of oxygen that disappears from the air in respiration, amounting to one-fifth, while it increases one-seventh in density, by combining with carbon in the formation of carbonic acid gas. But Mr Ellis even affords us facts himself, when treating of germination, that render the supposition of carbonic acid gas being actually formed in the living system still more probable: in page 23. he says, "We find accordingly, that the carbonic acid produced does actually exceed in weight the oxygen gas that disappears; and the carbon that occasions this excess can be derived only from the living seed; which, if the experiments of Hassenfratz are to be trusted, contains less carbon after germination, than it did before it was submitted to that process." Now, it will appear evident, that this excess of carbonic acid must have been formed in the body of the seed itself, and is most probably generated by the union of a portion of its carbon with the oxygen of the water contained in germinating seeds. Mr Gough found, that seeds, when beginning to germinate, emit a quantity of carbonic acid, even when oxygen gas is not present; although, for the continuance of this process, its presence is absolutely necessary. By experiments formerly taken notice of, it has been found, that carbonic acid is emitted in expiration, even when other gases than oxygen or atmospheric air has been inhaled. It has also been ascertained, that the quantity of carbonic acid is lessened below its usual proportion, when pure oxygen is inspired. And even by the experiments Mr Ellis quotes, from Huber's Essay on Germination, he admits the same conclusion, which that gentleman infers from them; and, in the 16th page of his Inquiry, repeats, that "a superabundance of oxygen gas also, although not destructive to germination, nevertheless retarded the process; for seeds were found to germinate better in a mixture formed of three parts nitrogen, and one of oxygen, than in a mixture composed of three of oxygen, mixed with one of nitrogen." These facts do not seem. to admit of explanation on the theory Mr Ellis has proposed. Upon the whole, in the respiration of animals, we do not perceive any material difference in the conclusion he assumes from his experiments, from that which was formerly suggested by Dr Crawford.

What has been already said of the absorption of the nitrogen of the atmosphere, may be esteemed as sufficient to establish a contrary inference to that which Mr Ellis endeavours to support: we shall however, in this place, give the following tables of Spallanzani's experiments, in confirmation of the opinion formerly adduced.

		Oxygen gas destroyed.	Carbonic acid gas produced.	Azotic gas destroyed.
1	snail	20	7	5
2		16	5	3
3		18	6	4
4		20	8	8

He repeated this experiment on four pair of snails, and the following is the result obtained in half the time required to cause the death of the former snails.

	Oxygen gas destroyed.	Carbonic gas produced.	Azotic gas destroyed.
1 pair of snails	20	3	2
2	$19\frac{1}{3}$	4	6
3	20	8	6
4	17	3	5

See pages 164. 145. of Memoirs on Respiration.

Mr Ellis does not appear to us to have been more successful in his examination of the processes of germination and vegetation: sufficient attention has not been hitherto paid, to ascertain fully the difference of the changes produced on the atmosphere, by what has been called by Dr Darwin the respiration and transpiration of vegetables. From the experiments Mr Ellis has conducted, it would appear, that in every case oxygen is attracted from the atmosphere, and carbonic acid is, in consequence, emitted: and in this respect he agrees perfectly with Scheele and Darwin. But, on considering the abundance of watery fluid at all times contained in, and constantly emitted by, vegetables, from the surfaces of their leaves during day, and the power of the sun's rays in decomposing this fluid, we are still inclined to suppose, that a portion of oxygen may be emitted in certain circumstances, while the hydrogen is retained, to aid in forming the colour of the plant, and to enter into combination with other matters, in forming the variety of vegetable compounds. Mr Ellis thinks, that the pernicious effects of the lime in Sennebier's experiments, were entirely in consequence of the absorption of humidity : but were this the true manner in which that substance operated, its pernicious influence must have been equally conspicuous, whether the plant is growing in the shade, or is exposed to the sun ; or rather, its influence must have been most deleterious in the former circumstances. Besides, Mr Ellis's own experiments respecting this question, are insufficient to afford a decided conclusion, as it does not appear, that he varied these in a manner by which the question can be determined. There is another part of Mr Ellis's opinion, which we shall take notice of: he supposes, that carbonic acid gas is in no manner unfriendly to living animals and plants, than as it deprives them of access to oxygen gas: we shall refer to the experiments formerly mentioned, whereby it appears to have had the most deleterious effects both on animals and plants, even when mixed with oxygen in considerable proportion. No doubt plants are not so speedily affected by being placed in contact with any of the irrespirable gases as animals; and accordingly we find, they continue to live for some time in all of them. With respect to the absorption or emission of other fluids, which Mr Ellis denies, we have no other observations to offer than those we have already made. The probability, if not the certainty, of the absorption of nitrogen in respiration, seems to be demonstrated by the experiments we have related: till we are therefore put in possession of a more complete series of experiments in contradiction of these, we cannot give our assent to the inferences which Mr Ellis presumes his experiments authorise.

The effects of electricity upon vegetation will be considered, when we come to investigate the influence of this fluid in occasioning variations of climate.

SECT. IV.

OF THE INFLUENCE OF THE ATMOSPHERE ON ANIMAL AND VEGETABLE REMAINS.

ANIMALS and plants, when divested of the living principle, may be preserved entire, in very high or in low temperatures of the air: in this way flesh and fish are preserved by northern nations during winter, by packing them in snow, without the aid of other means. This seems to be effected in consequence of the freezing of the humidity they contain, thereby preventing its decomposition, and the consequent reaction of its principles on the other component parts of those matters. The rapid extraction of humidity from inert animal and vegetable matters by means of heat, is likewise found to produce a similar effect; and in this manner the bodies of men and other animals that have perished in crossing the deserts of Africa, have been discovered in their natural appearance, after a lapse of many years. From these observations it would seem, that the moisture contained in the remains of organized matters, is the chief cause of their decomposition: this is further ascertained by finding, that the decay of such matters immediately commences, if, after having been frozen, they are again thawed, and exposed to a temperature but a few degrees above 32°, or when the necessary portion of water is added to such as have been dried by means of an high degree of heat. Matters preserved by drying, may be transported to any other climate, without undergoing any decomposition, if they are carefully preserved from the action of the air or insects, which may be easily effected by means of a varnish; while, on the other hand, similar matters preserved in a low temperature, can only be kept in an atmosphere below the freezing point. It is in this way that the process of putrefaction is supposed to go on, independently of the access of the air; however, there cannot remain a doubt, that if it does not wholly depend on the influence of that medium, it is certainly very much quickened by its agency, and the evolution of the process is thereby rendered more complete. The decay of animal matters, or their putrefaction, is prevented, by exposing them to the influence of certain substances, as by immersion in carbonic acid gas; this is even employed to restore tainted meat to a sweet state: all matters that have a strong affinity for water, as acids, alkalis, sugar, ardent spirits, answer the same purpose; and they probably do so, by being dissolved in the humidity contained in these matters, and in this manner they prevent its decomposition: they likewise seem to form new combinations in the other integral principles of the matters to which they are applied; this is manifest by the change of colour, smell, consistence, and taste, which matters thus preserved always acquire. But although water in a certain proportion is necessary to promote putrefaction, both in animal and vegetable matters, its superabundance is found to be equally powerful in preventing and restraining this process, as when it is contained in diminished quantity. It has been ascertained by Sir John Pringle and Dr Macbride, that small quantities of sea-salt promote the putrefactive process: this circumstance perhaps admits of explanation, from the great affinity for water, that subsists in the impurities with which culinary salt is always mixed; the necessary quantity of this fluid being imbibed from the atmosphere, it in this way counteracts the effects of the pure muriate of soda in restraining putrefaction, in the manner we have suggested.

When animal remains are exposed in a situation unusually moist, they undergo a change very different to what occurs in consequence of the process of putrefaction: the figure of the mass continues unchanged, though it is perceived to consist of principles entirely different, being now of uniform consistence throughout, and possessing all the properties of spermaceti: this change was first observed, by removing the bodies that were buried in the churchyard of the Innocents at Paris; and it was then found, that thirty years were necessary to complete this transmutation. The fact has been since confirmed by general experience.

It was originally known to Mr Boyle, that vinous fermentation proceeds, when the access of the atmosphere is precluded from the fermenting mass; and the truth of this observation has been very lately determined by Mr Collier, from the result of several experiments. The unfavourable influence of the atmosphere in that process, is probably occasioned by the operation of light, as already explained, when treating of the germination of seeds, whereby the oxygen of the sugar of the wort is probably extricated in too great proportion: the communication of the atmosphere must also have a pernicious effect, by causing the evaporation of the more volatile part of the fluid, by which the strength of the product must be lessened. But it is found, that the acetous fermentation only takes place when the communication with the atmosphere is free. In this case, the process is attended with an increase of temperature; oxygen gas is absorbed from the air, and carbonic acid gas is emitted from the fermenting liquor. In this way, it is found, that the stronger products of vinous fermentation never turn sour, when carefully precluded from the access of the atmosphere.

Animal and vegetable matters can be each resolved into the same ultimate principles,—oxygen, azote, hydrogen, phosphorus, sulphur, and carbon, some earths, and saline matters; but these enter into peculiar proportions, forming the specific distinctions of these two classes. Animal bodies in general contain a greater proportion of azote, phosphorus, and sulphur; while vegetable compounds have a greater quantity of oxygen, and probably of carbon and hydrogen. We shall therefore subjoin an outline of the putrefactive process in these respective classes of matter. It has not been determined, what precise changes the atmosphere undergoes, during the putrefaction of any matter freely exposed in it; the danger attending experiments on putrefying matters has hitherto prevented the subject from being examined with sufficient attention. A certain temperature and proportion of moisture are necessary for the accomplishment of this process. The former must be considerably above the freezing point: but vegetables seem to require an higher temperature than animal remains; and, in either case, it is necessary it should not be so great as to cause the rapid evaporation of their humidity. In these conditions, the body loses its colour, becoming of a blackish hue, the muscular parts turning soft and clammy: the mass soon after swells up, and a dark-coloured serum is discharged from it; air-bubbles frequently break upon its surface, which, in certain conditions, give it a frothy appearance. The gaseous matters that are emitted in this stage chiefly consist of watery vapour, carbonic acid gas, ammoniacal gas, hydrogen, holding in solution sulphur, phosphorus, and perhaps carbon. These appearances continue some time, always in proportion to the bulk and nature of the mass exposed, and the favourable state of other circumstances. It then begins to fall down, and to lose its form, while, at the same time, the nauseous putrid smell becomes seemingly increased, owing to the diminished quantity of watery vapour, carbonic acid, and ammonia, being succeeded by an increased evolution of the other gaseous products. At this period of putrefaction, the matters extricated are peculiarly noxious to the health of animals; and their force and virulence gradually abate, as the bulk of the putrefying mass disappears, till at last nothing remains but the earthy and saline matters, with a quantity of the carbon which had originally formed the basis of the composition of the body.

In the putrefaction of vegetable matters, nearly the same appearances take place; but in the aërial products, there is always a greater proportion of watery vapour and of carbonic acid and hydro-carbonate gases, and more rarely the appearance of ammonia, phosphoretted or sulphuretted hydrogen gases: therefore, the products from putrefying vegetables are never so pernicious as those which arise from the former description of matters undergoing the same changes. When vegetables begin to putrefy, their colour gradually changes, the leaves becoming yellow, soft, and easily torn; the whole mass increases in size, and the fibrous texture becomes soft, dark-coloured, with a considerable increase of temperature. The vapours emitted are frequently perceived to arise from it in this state: these are but rarely found to be offensive; and when this does take place, it is always towards the termination of the process, when the ammoniacal gas is extricated along with the hydrogen gas and watery vapour, &c. When these vapours are no longer given out, the mass becomes dry, of a brownish-black colour, and still retaining, in many instances, an outline of the structure of the former plant. This constitutes what is called vegetable mould or manure, and which consists in a great measure of the carbon, saline and earthy matters of which the plant was composed, and which, by distillation, is likewise found to contain oleaginous matters, besides those bodies we have mentioned in treating of vegetation.

Putrefaction takes place in animal matters, however deep they may be buried; only it is to be observed, that as the access of the atmosphere is not so free, their decomposition, and the evolution of the gases, are more gradual: still, the same aërial products are communicated to the atmosphere, where they must occasion prenicious effects. In this way, the impropriety of burying in churches, and having burying-grounds situated in the midst of cities, becomes evident; for, even in the most temperate climates, the baneful effects of the matters evolved from accumulated masses of putrefying bodies, are daily experienced; and, on that account, there is no subject has a higher claim to the attention of those who have the management of the internal police of cities.

CHAP. II.

GENERAL OBSERVATIONS ON THE INFLUENCE OF CLIMATE ON ANIMALS AND PLANTS.

SECT. I.

THE properties of the atmosphere, and its most evident effects on living matters, as a chemical fluid, having been investigated in the foregoing pages, the influence of the variations of its physical qualities on these two classes of natural objects, now claims our attention; when its power will be perceived equally great, and no less remarkable in its consequences. This forms a discussion on the influence of climate, —a subject which comprehends the effects of the atmosphere on animals and plants, according to the state of its temperature, gravity, humidity, and electrical fluid; together with the proportion and nature of extraneous matters occasionally contained in it; the proportions of caloric, vapour, electricity, and accidental impurities existing in the atmosphere, being found to constitute every variety of climate, and by which also fluctuations in its state of gravity occasionally occur. Winds chiefly alter the nature of certain climates, by occasioning variations in the temperature and state of humidity in the atmosphere; and in this manner, they induce variations in its density, and occasion similar effects upon animals and vegetables as the same conditions of the atmosphere brought on by the operation of any other cause. The peculiar effects of particular winds have been occasionally remarked, when treating of their natural history. It is proposed to premise a few general observations on the influence of climate upon living matters, but which do not immediately refer to any of those heads under which we propose to treat of the subject; and we shall conclude the work, with some observations on such matters as are occasionally found existing in the atmosphere, and which induce variations in its condition, by communicating something deleterious to its properties.

The extraneous matters most frequently found existing in the atmosphere, are carbonic acid gas, hydrogen and hydro-carbonate gases; and sometimes, though rarely, there has been perceived an over-proportion of the natural constituent gases of the atmosphere itself, in certain situations near to sources where they are evolved. But the extraneous matters most commonly detected in the atmosphere are effluviæ of different kinds, which arise from animal and vegetable matters under different states of existence: they are likewise most powerful in their effects, and produce the most deleterious consequences, by altering the nature of the climate. Of these, the most baneful arise from the decomposition of animal substances, of which we have already treated, or such as are emitted from the bodies of people labouring under particular diseases. This part of the subject, therefore, includes a consideration of the nature of miasmata and of contagion, which, being supposed to be allied in their effects, shall be treated of under the same section.

When treating of the effects of climate on man, Hippocrates observes, " Quicunque artem medicam integre adsequi vellet, primum quidem temporum anni rationem habere debet, quantum potentiæ quodlibet eorum valeat; non enim simile quicquam illis existit, verum differunt invicem propter varias quæ in eis fiunt mutationes." This is an observation which applies with equal propriety, and is not less necessary to be inculcated to the attention of the practical agriculturist. In the same book, *De Aëre, &c.* in lvii. this accurate observer of nature continues, " Temporum itaque varietates potissimæ sunt, quæ naturam ipsam permutant; deinde etiam regio in qua quis nutritur: postremum autem aquæ. Invenias enim fere semper et formas hominum, et mores regionis naturæ compares."

Animals and plants which are common to every country are perceived to vary in their appearances, and even to differ in their manners and other qualities, in the various regions of the earth. Every country seems therefore to possess some animals and plants peculiar to itself,—an effect evidently induced by the immediate influence of the atmosphere upon these bodies themselves, or upon the matters on which they subsist. But the atmosphere has not only a powerful influence upon the natural productions in different latitudes; there has even been remarked diseases peculiar to certain climates, and diseases vary in every country, according to local situation and season of the year: thus, the herpetic eruptions and typhoid fevers, prevalent during summer and autumn in temperate climates, correspond to the cutaneous diseases and febrile complaints so common in warm countries at all times. The influence of climate in this respect is perhaps most powerful in giving rise to those complaints which are supposed to be peculiar to certain countries, and which are constantly endemial in them, either in an acute or chronic state. In this way, scrofula, with all its direful concomitants, and phthisis, are said to be endemial in the British Isles; calculus and gout are thought to be more frequent in France; the goitre and cretanism prevail in the Alps, and in other hilly countries; lepra has been said to be common amongst some Asiatic tribes ; elephantiasis has been hitherto found in Egypt and Ceylon, or in the vicinity of large rivers within the tropics, which regularly overflow their banks at certain times of the year, leaving the adjacent grounds in a marshy state ; and there is likewise the peculiar disease of the hair, called plica Polonica, from the country where it is said to appear most frequently.

Alpinus mentions a very singular fact in illustration of the above circumstance, which has been confirmed by the observations of later writers on the climate of Egypt, in his Treatise *De Medicina Egyptiorum ;* he observes, that canine madness is unknown in that country ; and Volney says, that although the streets of Cairo are crowded with dogs, whose only resources are picked from the common sewers and gutters of the city, and are therefore often subjected to the most pinching famine, nevertheless, that dreadful malady has never been known to break out amongst them. There are some diseases which are observed to vary with the climate, and to appear more aggravated at certain seasons : this has been remarked to take place in a considerable degree in the appearance of syphilis. It was observed long ago by Guy de Chauliac, that wounds of the head were more difficult to cure at Paris than at Avignon ; on the contrary, sores on the legs were more easily healed in the former situation. A similar observation respecting the cure of ulcers, may even be traced up to the days of Hippocrates.

The influence of climate is so general and so powerful, that not only the physical qualities of animals and plants are varied thereby, but the same cause has likewise been supposed to determine the moral character of mankind. While it is perceived that the same species of animals and plants differ so widely in their external appearances in the great zones of the earth; the manners and faculties of man have been perceived to vary in a degree equally remarkable.

> "——— ma vari ancora
> Gli huomini di color molto, e di faccia
> Anno, e generalmente ogni nazione
> Vive alle proprie infermita soggetta."
> MARCHETTI's LUCRETIUS.

The vigorous health of animals, as well as the growth of vegetables, depend in a considerable degree on the habit of their constitution, with certain tracts of the atmosphere. This gives origin to indigenous plants in every country, and it has likewise a considerable influence in giving a turn to peculiarities in the manners of its inhabitants.

By this conformity of constitution in living bodies with the native climate, many apparently anomalous circumstances, in the practice of medicine and agriculture, admit of illustration. It is evidently owing to the power of constitutional habit, that either a warm or a cold atmosphere has a much less effect upon the natives or people accustomed to such a climate, than what is experienced by others. On the same principle it is found, that climates even the most unfriendly to strangers, are seemingly innocuous to its indigenous inhabitants. From a similar influence of climate upon the animal economy, the benefit accrues which people experience by returning to their native climates, who have had their health injured by living in a foreign country. It is probably to a similar effect of constitutional habit, that people exposed to certain impure states of the air, are not so liable to be affected by it as others. And it is apparently owing to this circumstance, that physicians and others, much exposed to an atmosphere loaded with contagious vapour, more rarely experience its pernicious effects in a degree equal to what it exerts upon others not so habituated: and it is likewise to this power of the constitution accommodating itself to the climate, that the decrease and disappearance of every epidemical disorder is to be imputed.

By adverting to the habit of plants with certain situations and climate, we are enabled to comprehend, why such as are raised from seeds brought from a climate where they come earlier to maturity, should vegetate and ripen sooner than others of the same kind habituated to the situation, where the temperature of the atmosphere is less genial: they are therefore perceived to retain this property with other qualities for some time, till, through a succession of crops, they degenerate in this respect, acquiring all the properties of indigenous seeds.

Plants which are natives of tropical climates, do not thrive, and soon degenerate when transplanted into the temperate regions of the earth. On the contrary, the natives of a cold country never vegetate so vigorously, when transplanted into a situation where the mean temperature of the atmosphere is much greater: and there are some plants which even refuse to grow but in the most chilly climates.

Pallas found, that potatoes, cauliflowers, and water melons, had degenerated even at a little distance from the shores of the Caspian sea. Every writer on the climate of Egypt mentions a similar fact, respecting the indigo plant. The Baron de Tott expressly says, that those who cultivate this vegetable, finding that it degenerates there so quickly, are under the necessity of getting a supply of fresh shoots yearly, from some of the islands in the Mediterranean. M. Volney, whose scientific knowledge and correctness of observation are of the highest respectability, likewise takes notice of the same fact more generally, in the following words: "Les plantes étrangeres degenerent rapidement; ce fait est constaté par experiences journalieres: nos negociens sont obligés de renouveller chaque année des grains," &c. He continues to remark, that those seeds do well enough for raising a single crop; but on planting them a second time, they are found to become stunted in growth, losing their natural green colour, acquiring the appearances of plants that have been raised in the dark. It has been already observed, that the singular effects of climate are not confined to the vegetable kingdom; every class of animals partakes of its influence.

Aristotle has related, in the 29th chapter of the 7th book of his History of Animals, that "morum etiam diversitatem loca efficiunt; ut montana et aspera suas tristius reddunt, et aspectu efferatiores et viribus robustiores, quam plana et moliora." And, according to the same author, the wolves and some other animals common to Egypt and Greece, are of less size in the former climate; while others, as oxen, are larger.

The fleece of the same species of sheep varies greatly from this cause; in a temperate or cold country, the wool grows extremely soft and silky; in warm countries, it becomes more coarse, and even resembles hair. Indeed, this is so manifest in certain species of sheep in Britain, that it has been remarked, that "every filament of wool is greatly altered by heat, or the cold that the animal producing that wool is subjected to during its growth; that part of the wool being always coarsest, which is produced in warm weather, and finest in cold weather."—See Bath Society Papers, vol. v. And it is equally probable, that the animals which bear fine wool of a silky lustre in warm countries, would suffer an equal degeneracy in the quality of that substance, on being exposed for some time to a climate of a lower temperature.

The climate of Egypt has a very remarkable effect on certain classes of mankind, although man, from his various resources, is better able than other animals to resist its powers, and who can, from his nature, more easily adapt himself to the varieties of the atmosphere every where. The Mamelukes, who are commonly natives of some of the more northern provinces of the Turkish empire, although they are carried into Egypt when young, and of course should on that account be more perfectly habituated to the climate and the manners of its inhabitants; yet it is a general observation, that these men rarely leave any offspring. Mr Brown, in the account of his Travels through Egypt, has the following remarkable observation; "Of eighteen Beys, whose history I particularly know, only two had any children living." M. Volney likewise mentions this circumstance; and in a more particular manner he says, "Depuis cinque cens cinquante ans qu'il y a des Mamlouks en Egypte, pas un seul n'a donné lignée subsistante; il n'en existe pas une famille à la seconde generation; tous leurs enfans perissent dans la premiere ou la seconde age. Les Ottomans sont presque dans le même cas; et l'on observe, qu'il ne s'en guarantissent qu'en epousant les femmes indigenes; ce que les Mamlouks ont toujours dedaignées." In relating this fact, the author points out the most effectual means of averting its peculiar consequences. An observation of a similar kind respecting the Scythians, has been mentioned by Hippocrates; but the sterility in this instance could be readily traced to the operation of different causes, and seemingly totally independent of the influence of the atmosphere.

On the subject of climate, Lord Kaims makes the following observation: " Several European colonies have subsisted in the torrid zone of America more than two centuries, and yet even that length of time has not familiarized them to the climate; they cannot bear heat like the original inhabitants, nor like negroes transplanted from a country equally hot; they are far from equalling, in vigour of mind or body, the natives from which they spring. The Spanish inhabitants of Carthagena, in South America, lose their vigour and colour in a few months; their motion is languid; and their words are pronounced in a low voice, and with long and frequent intervals. Europeans who are born in Batavia soon degenerate: scarce one of them has talents sufficient to bear a part in the administration; there is not an office of trust or figure but what is filled with native Europeans. Some Portuguese, who have been settled for ages on the coast of Congo, retain scarce the appearance of men." But the Abbé Hell gives a still more remarkable instance of the power of climate in altering the appearances of certain races of mankind. This philosopher was by birth an Hungarian; and during his stay in Lapland, he ascertained that the natives of that country are descended from the Tartars, in like manner as the Hungarians. Most of the nations inhabiting the north, and even the meridional countries of Asia, seem to derive their origin also from the Tartars; and amongst these races of men, there are few traits of resemblance either in their manners or appearance; the same race of men inhabiting high northern latitudes being found of a puny figure and deformed aspect, with a corresponding deficiency in the energy of their intellectual powers; while those occupying climates nearer the tropics are tall, athletic, and of a handsome visage, possessing every advantage of mental faculty and of exterior appearance. The evolution of the physical powers of man, depends intimately on the influence of climate; wherever this is mild and genial, there he acquires his utmost degree of perfection, both in corporeal and intellectual faculties.

We have only to consider the differences that exist amongst the tribes of native Americans, to be convinced of the power of climate upon the faculties; as, probably, that division of the globe has been wholly peopled from the same original race. Buffon observes, " That however remote Cashemire may be from Spain, or Circassia from France, yet, situated nearly at the same distances from the equator, the resemblance between the natives is singularly striking." Indeed, we have only to take a comprehensive view of the inhabitants of Europe and America, lying under the same parallels of latitude, to be convinced of the power of the physical properties of the air in this respect.

Certain vegetables are raised for their nutritious qualities in certain climates, which in a different situation, or by varying the mode of cultivation, suffer a considerable alteration of their properties. It is owing to this cause that the qualities of wheat, barley, and other corns, raised in different districts even of the same country, vary so considerably, although the seed from which they have been raised, may have been the same in both instances. All those plants which in their produce afford bread-corn, have evidently been transplanted from the warmer regions of the earth, where they are probably indigenous. This seems to be confirmed by finding, that some of those which are raised annually in the north of Europe, have been frequently observed to be perennial in climates nearer to the tropics, as in Sicily, Egypt, &c. Plants, like animals, do no thrive when suddenly transplanted from one climate to another remarkably different: therefore every species of corn must have been gradually introduced into the temperate and colder latitudes. This is rendered extremely probable, by what is known to have happened in the cultivation of rice, which is a hardy plant, and even comes to maturity in meridional latitudes of the temperate zone; but it has been found indispensably necessary, in attempting to raise this plant in colder situations, to habituate it gradually to a climate of a diminished temperature, by a few years previous cultivation in several intermediate latitudes.

Having premised these general remarks on the influence of climate, we shall now proceed to investigate the subject more particularly in the order laid down.

SECT. II.

OF THE INFLUENCE OF VARIATIONS OF THE TEMPERATURE OF THE ATMOSPHERE, AND OF DIFFERENT STATES OF ITS GRAVITY, UPON ANIMALS AND PLANTS.

The influence of atmospherical temperature upon living bodies, is similar to that produced by heat in general, and is manifested by the strongest stimulant effects varying in degree, according to its permanence and intensity; and within certain limits, it is essentially necessary for continuing the functions of the animal and vegetable economy. This general effect of heat is demonstrated by what takes place with regard to dormant and emigratory animals; a certain degree of atmospherical temperature being necessary for continuing their functions, but which is confined within a very narrow range: an apparent indolence and sluggishness in their motions gradually supervene according as the necessary degree of temperature declines. Some animals, as birds, by the power of instinct, immediately seek refuge in a more genial climate, as the cold weather begins to set in; while other animals, who, by their organization, are incapable of pursuing a similar mode of protecting themselves from the increasing cold, take shelter in burrows and holes, so accommodated, as not to be liable to be affected by any sudden change of temperature in the atmosphere. It is regularly observed, that dormant animals leave their burrows in the spring, when the temperature of the atmosphere is even lower than when their dormant state supervened. This has been explained, by supposing those animals are in this situation more susceptible of the impression of heat, after being deprived for a considerable time of the influence of that matter.

In proof of this opinion, it has been ascertained, that the temperature of the air is always higher when these animals come abroad, than the temperature of the burrows during winter, where they had remained. The peculiar effect of climates varying in temperature, is familiarly demonstrated by the changes which take place in the alertness of the Lascars, or native Indians, in the course of a voyage to Britain, or from this country to India. In the voyage homeward, they gradually become less active and dull, as they approach the northern latitudes; and in an outward bound voyage, their capability of exertion and activity increase in proceeding towards the equator.

On the same principles, the budding and falling of the leaves of trees, has been attempted to be explained; plants being evidently susceptible, in a certain degree, of the stimulant nature of heat, in a manner similar to the former class of beings. As the heat of summer declines, the circulating vessels in the foot stalks of the leaves become incapable of being excited, in consequence of the increasing diminution of temperature of the air. And towards the end of autumn, the leaves therefore gradually lose their colour, by their sap evaporating; and in this state, they fall to the ground, by the motion of the slightest breeze.

Again, the leaves are perceived to bud in the spring, at a much lower degree of heat in the atmosphere, than when the former circumstance occurred: this appearance also admits of explanation, from the increased susceptibility of sensation to the impression of matters to which the organ has been for some time unaccustomed, as in the foregoing instance of the revivification of dormant animals.

The doctrine of the stimulant nature of heat is perhaps most distinctly illustrated by attending to the influence of a low temperature of the air upon living matters, the effects in this case being opposite to those produced by a warm condition of it. Cold, or a low degree of heat, is justly accounted a most powerful sedative, not that it operates by abating or destroying the nervous energy by a direct impression of its power: it merely effects the same purpose, by lessening or abstracting the proportion of a stimulus, which, in a certain degree, is essentially necessary for the continuation of life. It is therefore probable, that, from the uniform repellent property of heat, and its tendency to enter into union with every substance, more or less rapidly according to the degree of affinity subsisting between it and other matters, that as the temperature of the atmosphere approaches to that of the living body, of course it will suffer a continued accumulation of caloric, till they nearly approach to an equilibrium: the body thus exposed to the influence of the air, will suffer a considerable degree of over-excitement; and therefore whatever acts by abstracting any portion of this superabundant heat, will, by relieving the system of its oppressive effects, have the appearance of acting as a stimulant. It is in this way, that the application of cold air or water evinces occasionally powers of a tonic or stimulant nature. By this doctrine, we also understand why a sudden application of cold proves in many instances immediately fatal, when the body has been overheated; as by taking a draught of cold water, whey, or cold drink of any kind. In this case it appears, that the too rapid deprivation of caloric from an organ so exquisitely sensible as the stomach, and with which every other organ of the body partakes of an intimate sympathetic affection, proves thereby fatal to the general system, but which would not be followed by any ill consequences, were it exhibited gradually, or were the matter at a low degree of heat possessed of stimulant properties of a different nature, or applied to an organ of less delicacy, and whose universal sympathy is not so remarkable. On considering the effects of different degrees of temperature, we are enabled to comprehend, why a mortification takes place in a limb that has been chilled, or frost bitten as it is commonly called; and likewise why a slight increase of temperature should have a very powerful influence upon an organ thus affected. By stimulating it beyond its powers, it brings on a high degree of inflammation, which generally ends in mortification, with all its direful consequences.

The illustrious Bacon gives a very distinct explanation of this case, in the 788th page of the 1st volume of his works: he there observes, "that in the cold countries where men's noses and ears are mortified, and as it were gangrened with cold, if they come to a fire they rot off presently. The cause is, for that the few spirits that remain in these parts, are suddenly drawn forth, and so putrefaction is made complete; but snow put upon them helpeth, for that it preserveth those spirits that remain, till they can revive, and besides snow hath in it a secret warmth." By the above doctrine it may likewise be understood, why an abstinence from every thing that stimulates the body, is most conducive for the preservation of health, in those living in hot climates; as whatever adds to the natural influence of the climate, will, in a corresponding degree, tend to aggravate its effects. In this way, every attention should be paid to the dress, so that it may not oppress by its warmth; and likewise high-seasoned dishes, and the use of strong wines, ought to be carefully avoided, as also violent exertion of any kind, especially in the sun.

When living animals are subjected to the influence of a climate of an high temperature, an increased determination to the skin takes place, and probably the secretions of the system are generally augmented; owing to this effect, the inhabitants of a warm country are supposed to have a more lax conformation of muscular fibre, and to have therefore a more slender and weaker frame of body, and are consequently more inclined to be inactive.

According to this doctrine, men inhabiting temperate and cold latitudes, must possess a very opposite constitution of body; as there is no cause more powerful in repressing the circulation through the minute superficial vessels, and in abating the activity of the secreting organs, than a low temperatureof the air: the secretion by the skin is thereby proportionally lessened, and the blood circulates with greater force through the internal viscera. Northern nations, from this circumstance, have been supposed to have a thicker and higher coloured mass of blood, with a greater firmness of muscular fibre, and consequently to possess greater strength, and to be more disposed to active pursuits. Nevertheless, the effect of heat upon the living system, is liable to considerable modification, according to its influence on the sentient extremities of the nerves. For it must be kept in view, that the immediate impression of the temperature of a climate, as well as every other external agent, is upon the nervous system of animals, and its most common effects upon the other organs can be always traced to this source, and will be regulated according to its force, and period of its duration. It is owing to the stimulant property of heat, that the delicacy of the sensation of touch is more exquisite in these climates during summer, and in warm countries at all times, the sentient papillæ formed by the nerves of the fingers being thereby kept moist and in a state more apt for impression. Hence the superior ingenuity and delicacy in the workmanship, and the more elegant fabrics of every article of manufacture of people inhabiting a warm climate.

The range of atmospherical temperature within which animal and vegetable life is preserved capable of reproduction, has not been ascertained; this probably varies in every species of animal and plant. Every region of the earth has been discovered to be tenanted with inhabitants; the deserts of the torrid zone, as well as the chilly regions within the arctic circle, have each their respective animal and vegetable tribes. Nevertheless, the general productions of nature increase in variety, and arrive at the most perfect condition, in countries where the temperature of the air, in every season, is mild and genial; and they decline in their properties, where the climate alters in any remarkable degree from this condition. We have formerly mentioned, that eggs and seeds resist the effects of the usual temperature at which inanimate matter freezes; but whenever the cold becomes so excessive as to reduce them to this condition, their reproductive qualities are thereby completely destroyed; and on being thawed, their properties are found entirely altered, the process of freezing having seemingly wrought a chemical change in their principles, which not only renders them less nutritious, but in other respects improper as an article of food.

Probably well-dried grain never suffers this change; when it does become frosted, in almost every instance it must be owing to a quantity of water contained in its substance. It is in consequence of the freezing of the water contained in germinating seeds, that the failure of the malting process takes place in very cold weather. Germination therefore succeeds most perfectly, at those seasons of the year when this occurrence is not apt to take place, and when the atmospheric temperature is not so great as to cause the evaporation of the water in too great proportion, which the grain has imbibed: it has accordingly been found, that spring and autumn are the seasons best adapted for the malting of grain. It is by the freezing of the humidity which succulent vegetables contain, as cabbages, turnips, apples, potatoes, &c. that they are so frequently destroyed by the effects of cold weather in winter.

Growing plants seem not only possessed of a power of resisting the usual freezing degree of cold, but of even coming to maturity at very low degrees of atmospherical temperature. Dr Roebuck observed in autumn 1783, that towards the end of October, the oats were still green; and one night in the beginning of that month, the frost was so intense as to form ice three-fourths of an inch thick, in the vicinity of Kinniel House, about twenty miles west from Edinburgh: the average heat of the whole month was only 43°, nevertheless he found, that in that low temperature of the air the oats filled greatly.

M. de Flauguergues of Montpellier, conducted an experiment which forcibly proves the correctness of the foregoing observation; on the 28th January 1778, he pulled up by the roots, three plants of oats and three of rye, and immersed them in a bason of water, placing it in a northern exposure, where it remained till the 2d of March following. During this interval the plants were frequently exposed to hard frost; four of them were destroyed by accident, but the two that were preserved continued to thrive very well on being transplanted into the soil, and proved very productive.

Although these observations show, that certain species of corn will grow and even maturate after the process of vegetation has fairly commenced, and after having been exposed to a temperature below the freezing point, it does not therefore follow, that the fruits will be equally abundant, or of an equal quality, in such instances, as in those plants which have been exposed to the power of a milder climate. On the contrary, it has been affirmed, that the qualities of the produce of the different plants of bread-corn, are not only less abundant, but inferior in other respects to the same species of grain raised in a more southerly latitude or warmer district.

Plants covered with snow are capable of suffering a much higher degree of cold, than when otherwise unprotected. There are many of the lichens and mosses which only thrive in the coldest climates, and continue to live even when the temperature of the air is far below the freezing point. These are commonly scraped up from under the snow by the rein-deer, and animals which subsist upon them. It was in consequence of the want of this protecting covering of snow, that many Lapland and Alpine plants perished in the botanic garden at Upsal by the cold of winter, although it was not more intense than what prevails for a great part of the year in their native situations: but, in those climates, the fall of snow commonly commences with the diminished temperature of the season; and in this manner, it affords a protection to the vegetable tribes against the increasing coldness of the weather.

There are plants peculiar even to the coldest climates, which only come to maturity in such situations, and which continue in leaf all the year. From this circumstance, they are called evergreens; and there are plants of this kind to be found in every country; but the variety of such plants decreases in latitudes approaching the poles. The evergreens peculiar to cold climates are frequently found in the warmest countries; but they are always in situations where the atmospheric temperature corresponds with that over their native soils. In these circumstances, Alpine plants, and evergreens of high northern latitudes, are discovered in mountainous situations even under the equator. It is evidently owing to this circumstance, that both the animal and vegetable tribes common even in the highest latitudes of the temperate zone, are frequently met with in every latitude; while, on the other hand, those peculiar to a tropical climate are never to be met with in countries greatly differing in temperature from that of their native air.

Dr Hales gives the detail of some experiments, by which it would appear, that the proportion of humidity transpired by evergreens is never so great as from other plants.

There are plants which, in the south of Europe, bear at the same time leaves, flowers, and fruit, and these through every season successively; they may therefore be considered as evergreens. No plant of this class can be transplanted into a colder climate, without undergoing an almost immediate change: even those which are most hardy, and where every care has been taken to habituate them to the climate, never bring forth flowers of so vivid colours, nor is the flavour of their fruit equally delicious, as those which ripen in their native soils; neither is the aromatous principle so strong; and they are accompanied with a corresponding diminution of their other sensible qualities, even although every means be used to produce a temperature in the atmosphere surrounding them equal to that of their native climates.

It is in this manner the temperature of the atmosphere is to be considered as occasioning a peculiarity of vegetables in different climates; the luxuriancy of vegetation in warm countries being supposed to be owing to the more direct influence of the heat communicated by the solar rays: nevertheless, there are seemingly other circumstances which must give a very effective co-operation to this cause, as the greater quantity of vapour in the atmosphere, and the richness of the soil, containing a greater proportion of matters fit for vegetable assimilation. But it is likewise to be observed, that a difference in the temperature of the atmosphere, not only alters the properties of vegetables, but, as we have already remarked, it likewise increases their varieties. The most powerful drugs, the most nutritious fruits, and vegetable poisons of the most deleterious kinds, are produced in climates within the tropics. On the contrary, in high northern latitudes, if nature has denied an equal variety of nutritious fruits, she has benignantly rejected from those climates a corresponding proportion of such plants as, by their remarkable poisonous properties, would have lessened considerably the comforts of their inhabitants.

In the 5th vol. Manchester Memoirs, Dr Guthrie has remarked, that the Gossipium hirsutum, or cotton plant, is perennial in the warmer provinces of America, but is annual in the colder. The Gossipium herbaceum is sown and reaped twice a-year in hot countries, and once a-year in colder climates. In addition to these observations, tending to illustrate the power of atmospheric temperature upon growing plants, we find, that M. de la Hire has shown, in the Mémoires de l'Academie des Sciences, that the figs of the southern provinces of France, of Italy, and of Malta, are perfect in their fructification during summer, and therefore ripen seeds capable of reproduction; but, seemingly from the lesser degree of heat, the seeds of fig-trees raised in the same situations during autumn are not prolific; and it is in consequence of the too low state of atmospheric temperature, that fig-trees can only be propagated by grafts or suckers in the more temperate European climates; the dust of the anthers which come forth in those situations not being prolific, of course, they cannot maturate a perfect seed.

The motion of the fluids in vegetables is probably owing, in a great measure, to the stimulant effects of heat upon their circulating vessels; and, like the perspiration of animals, transpiration will therefore be in proportion to the vigour of the circulation through the minute vessels. It is in this way, therefore, that the influence of the variations of the temperature of climate upon growing plants admits of explanation. A plant accustomed to an high degree of atmospherical temperature, when exposed to a climate of a greater degree of cold, suffers a corresponding diminution in the force of the circulation of its fluids, and in the quantity of matter transpired: every function of the plant becomes more torpid; of course, the different organs being imperfectly nourished, it gradually degenerates and decays. Vegetables peculiar to a cold climate, when exposed to a warm atmosphere, having their quantity of transpiration augmented, by the increased force of their circulation beyond what the natural state of the functions can admit, or which can be supplied by the quantity of matters absorbed by the roots, they in like manner become languid, wither, and die. The functions of animals being apparently more various and distinct, and, besides, being possessed of locomotive powers, they are thereby enabled to shelter themselves against the vicissitudes of atmospherical temperature; and they are therefore found to be likewise capable of submitting to more sudden changes of climate, without suffering immediate injury.

It has been already remarked, that the temperature of the air is not less remarkable in its effects on animals, than what it produces upon the vegetable tribes; their disposition and manners being perceived to differ according to the alteration induced by it upon their physical characters. Man suffers in these respects perhaps in a greater degree than any other animal; the changes produced upon him by the influence of climate being even in so remarkable a manner, that some eminent naturalists have maintained there has been originally several varieties of the human race. The colour, the figure of the countenance, the contour of the limbs, and the general shape and mein of the body, differing in infinite variety, have induced them to assume this opinion.

A full discussion of this question does not fall within the limits of our present subject. The view we shall necessarily take of it will, however, rather tend to show, that, in many instances, the power of climate must have a very considerable influence in occasioning those varieties of appearance, disposition, &c. which are peculiar to the natives of every country. "From the descriptions we have given," says the celebrated Buffon, " it is also evident, that the colour depends principally upon the climate, and that the peculiarity of the features depends greatly on the customs prevalent among different nations."—" No stronger proof can be adduced of the influence of climate upon colour, than finding, under the same latitude, and at the distance of 1000 leagues, two natives so similar as those of Senegal and Nubia ; and also, that the Hottentots, who must have derived their origin from a black race, are whiter than any other Africans, because the climate in which they live is the coldest." The correctness of the above remark will be generally admitted ; nevertheless, it is to be observed, that the fairest people are by no means those who inhabit the highest latitudes ; neither does it appear, that the varieties of colour even in the human race can be entirely imputed to the power of the sun's rays : thus, we find people of an olive or brown colour living in the very same situations with other casts which are entirely black, and whose features are different. It is likewise observed in the colour of animals, that their feathers and hair are always more variegated and higher coloured amongst such as inhabit an intertropical climate, than in the same species found in higher latitudes towards the north : however, those parts most exposed are not always possessed of the brightest hue. And were the colour of the feathers and furs of animals really owing to the influence of the solar rays, we should expect to see them still more uniform in the different species. The white colour of the hair of the breast and inside of the legs of dogs, has been supposed by Dr Darwin to be occasioned by pressure, from the particular posture of the animal in the uterus.

Scheele has observed, that the nereis lacustris is of a red colour when it lives in the sun, and becomes white when it is confined for some time in the dark. A similar effect is induced on other insects by the same means : thus, slugs, worms, and animals which live in wood, are generally of a whitish colour. This peculiar effect of light has been supposed to be manifested upon many other animals, as in those which change the colour of their furs in high northern latitudes, some being black at one season of the year, and white in the opposite season. The power of light is also shown in other respects upon animals supposed to be destitute of the organs of vision, or who see but imperfectly, as in bats, moles, &c. who are most commonly seen abroad only when the light of the sun begins to disappear, or when that luminary is wholly absent from the horizon. But even the shades of colour which animals possess who live almost wholly in the dark, afford a strong presumption against the generally supposed opinion of the effects of the solar rays in this respect. The late ingenious Dr Darwin seems to suppose, that the influence of solar light in changing the colour of the skin, is in consequence of the power it possesses of decomposing water; by extricating the oxygen, the hydrogen gas remains in union with the integuments, and occasions the tanning or colour.

It does not require any particular instance to show, that men of a foreign race acquire the colour and general appearances in the course of a few generations, and become almost in every respect similar to the aborigines of the country into which they are transplanted.

The Jews every where, and particular religious casts among the Mahomedans, are seemingly exceptions to this remark: but, in these cases, the effect of climate is counteracted, and the identity of character kept up, by the operation of other causes nearly as powerful. Richard mentions, that the descendants of the Portuguese who first settled in Africa, on the Senegal, are now become as black as the negroes; and the Saracens, Moors, and Arabians, who first occupied the west of Africa, from being originally white, tawny, or yellow, are now become quite black.

In hot countries, both the mental and corporeal faculties of man, the physical powers of other animals, and their acmé of maturity, are acquired much earlier than in temperate climates: on the other hand, they begin to decay at a much earlier period of life; this circumstance is perhaps most remarkable in the exterior appearance of man: in some countries the female sex is found to be marriageable at ten, and even in some instances at eight years of age; but this premature state of the faculties is always followed by a corresponding quickness of decay, these women appearing old, and grandmothers by the time they have reached little more than their twentieth year. The period of this apparently premature state of the faculties, is gradually prolonged in every country as we approach the poles; and accordingly we find, that the beauty of the fair sex fades earlier in those inhabiting a country possessing but a few degrees more of average heat: thus, in the south of Europe, the women appear getting old at a period of life, when those in the northern parts of France, in Germany, and in Britain, enjoy the bloom and freshness of youth. It was long ago remarked by Hippocrates, of the inhabitants of warm climates, "et clara voce præditi sunt homines, et ad iram et intelligentiam præstantiores, quam septentrionalibus, siquidem et alia quæ in ipsa nascentia mitiora existunt." viii. *De Aëre, Aquis et Locis.* Amongst northern nations, the voice is perhaps also less capable of inflexion; hence, our public singers are generally natives of the south of Europe. The form and sound of languages varying so widely amongst people inhabiting different countries, have been also imputed to the effects of climate. The cold contracting the organs of speech, and thereby impeding a free pronunciation, has been supposed to occasion the harsh monotonous language of northern nations; while an opposite state of the temperature of the air, admitting a free enunciation of sound, has given rise to the liquid and musical pronunciation of people inhabiting a warm climate.

But the external characters are not alone affected by the influence of climate; a warm temperature of the air is perceived to produce an effect upon the mental faculties no less remarkable than the changes we have already noticed. The influence of different states of atmospheric temperature upon the passions, has been remarked by the very earliest writers, and affords a most important subject of inquiry to every one interested in an investigation of the properties of the human mind. Even the changes of seasons, and every incidental variation of weather, have a striking effect upon the mental faculties of every one. There is not a more common observation, than to hear of the effects of different states of the atmosphere upon the spirits; and there cannot be a doubt, that changes from a rare to a more dense state of the atmosphere will have a proportionate effect in varying the degree of pressure upon the surface of the body, which will thereby induce corresponding effects upon the energy of the mind. It is probably in this way the sol-lunar influence affects both animals and plants. It has been mentioned in the earliest records of science, that the influence of the moon has a very considerable effect upon all sorts of vegetable productions. The powerful effect of moonlight in ripening the grain, seems to be a remark coëval with cultivation. It has been observed, that in the West India islands, all sorts of vegetables are fuller of sap at the times of new and full moon: the colonists therefore carefully abstain from cutting wood for the purposes of cabinet-work at these periods. On the other hand, these have been reckoned the fittest seasons for gathering sugar-canes and castor-oil nuts; and it is said, the latter even yields a fifth or a fourth more oil in these circumstances. And it seems probable, that in consequence of the accumulated pressure of the atmosphere from this cause, old and valetudinary people are found to die most frequently about the great lunar periods,—an event which oftener occurs during the winter season and in cold weather, when, from the absence of the necessary degree of stimulus from atmospherical temperature, weak people are thereby less able to resist any additional burden from the increasing gravity of the air. This will readily appear, when it is considered, that Haukesbee found the gravity of the air increased one-eight by this cause alone.

A low temperature of the atmosphere has been supposed to render mankind less irascible and more stubborn: accordingly, in the northern latitudes of the temperate zone, melancholy, and a desponding state of mind, are more frequently met with than in warm countries. But a diminution of atmospherical temperature has a more powerful effect upon strangers from within the tropics, whether natives, or those who have passed a considerable part of their lives in a warm climate. The venerable De Thou records this particular influence of a low temperature of the atmosphere upon the mind, in the character of Henry III. of France. That prince, naturally of a pleasant temper, and of a gay disposition, was uniformly remarked to be capricious, irascible, and even cruel, during the prevalence of cold weather; and his historian affirms, that it was during the influence of this effect of cold that he commanded several harsh measures to be executed, and especially instances the order he gave for putting the Guises to death,—a circumstance he afterwards severely repented. There is, no doubt, that a diminished temperature of the air has a remarkable effect upon very young and delicate people, rendering them fretful, and sometimes gloomy and desponding. These effects have been perceived to be most remarkable in irritable habits, and in men whose ordinary state of mind is gay and lively. It has accordingly been observed, that people living in high northern latitudes have commonly less vivacity and quickness of thought; and their mental faculties in general are said to be more dull.

On the other hand, a high temperature of the atmosphere has been said to have sometimes an effect somewhat similar upon the minds of people unaccustomed to great heats; and there is no doubt, that on account of the increased celerity of the circulation alone, it must produce a considerable effect upon the mental faculties of such men. But in this instance, it probably acts by increasing the natural energy of the mind, causing a degree of impetuosity in the passions: it frequently renders a sour morose disposition cheerful, creating an amiable vivacity of temper, with all the passions peculiar to a sanguine temperament. Dr Moseley takes notice of a curious fact, respecting the influence of a tropical climate upon the mental faculties; he asserts, that it improves the mind, and sublimes the ideas of those sent out from Europe; that idiotism is totally unknown in the West Indies, mania but rarely, and that the faculties of the African are always improved in that country by a second generation.

" People of delicate nerves and moveable spirits, are often joyful, sullen, sprightly, dejected, hopeful, despairing, according to the state of the weather; and these changes happen, but pass unobserved in stronger constitutions. There are days in which the intellectual faculties of memory, imagination, judgment, are more vigorous; therefore it seems probable the genius of nations depends upon that of the air. Arts and sciences have hardly ever appeared in very great, or in very small latitudes. The inhabitants of some countries succeed best in those arts which require industry, and great application of mind: others in such as require imagination. From hence, some countries produce better mathematicians, philosophers, and mechanics: others better painters, statuaries, architects and poets; which, besides the rules of art, demand imagination. It seems to me, that labour is more tolerable to the inhabitants of colder climates, and liveliness to those of a hot." The above is a statement of the opinion of Dr Arbuthnot, on the subject of our present investigation; and we shall now proceed to examine how far it depends correctly on the facts we shall adduce in support of the theory of atmospherical temperature we have premised.

The very opposite effects of the temperature of the atmosphere upon the mental faculties, has afforded a fertile subject of discussion; and an opinion has universally prevailed, especially since the writings of Montesquieu have been so generally disseminated, that a warm temperature of a climate enervates the energies of the mind.

This opinion seems to have been entertained by philosophers, even in the earliest periods of antiquity. Herodotus, in the ninth book of his history, records the speech which Cyrus addressed to the Persian ambassadors, of which the following is the sentence which particularly refers to the present question. "Si posthac præpararunt non ad imparandum aliis amplius, sed aliis parandum. Natura enim comparatum esse, ut e mollibus regionibus molles viri existunt, non ex eadem terra admirandæ fruges et egregii bello viri gignuntur." But this opinion, although supported by authorities so highly respectable, is not agreeable to general observations upon men in the present day, and differs widely from what should be inferred from historical facts handed down to us, respecting the manners of mankind in various climates at different æras of the world.

It is very well known, that in the meridional countries of Asia, both the religious and political systems of their inhabitants are rather calculated to depress the vigour of the mind, and even to debilitate the reasoning faculties. We therefore find, that in those climates which were formerly peopled by men of the most active and enterprising dispositions, their present inhabitants seem to have sunk into the most deplorable state of inactivity and mental indolence.

It was an old Roman saying, "neminem triumphasse sine Marsis," the Marsi being the most warlike of the ancient inhabitants of Italy, although they occupied its most fertile territories, but which are presently possessed by men whose faculties are extremely different. Indeed, the whole of that delightful country is now peopled with inhabitants who neither enjoy the same activity of body, nor the energy of mind, in any degree equal to those faculties of its former possessors. It may be superfluous to repeat, that the ancient inhabitants of Italy were a brave, warlike, and ingenious people; the admirable monuments of the arts, and of their industry, which have reached the present times, prove them to have possessed the most refined taste, and to have been capable of the most astonishing exertion. Their writings, which still remain after the lapse of so many ages, and which have escaped destruction from the no less pernicious effects of barbarism and slothful ignorance, are still regarded as the models of elegant diction, and of political and moral sciences.

The description which Sallust gives of the manners of the people of Africa in xvii. Jugurthine war, affords a faithful proof of their energy of mind: he says of them in general, they were "genus hominum salubri corpore, velox, patiens laborum." The Roman historians bear witness to the activity of the Carthaginians, inhabiting a warmer climate, and who do not seem to have yielded to their contemporary inhabitants of Italy, either in bravery, enterprise, or political science. Their reputed discoveries in navigation, and their commercial spirit, evince them to have possessed the highest mental powers, and to have been capable of the greatest bodily exertion. The destruction of the Carthaginian empire must naturally have had a powerful influence in retarding the civilization and progressive improvement of mankind, and is an event that will ever be regretted by the humane and liberal; while the wretchedly selfish policy which suggested and approved that measure, can only excite feelings of indignation and scorn. The people possessing the country around the present site of Constantinople were brave, and by no means found enervated when invaded by the Romans.

Greece is a climate the most genial in every respect for the production of the most necessary articles of food, and the growth of the most exquisite fruits; indeed, it seems to comprehend every thing that is necessary for the most perfect enjoyment of life. In former times its inhabitants were restless, brave, adventurous, and lovers of the arts and sciences: Greece seems in those days to have been the country, where, with personal beauty, and every corporeal and mental faculty, man acquired the highest perfection: it long continued to be the nursery of science; and in its inhabitants we meet with examples of virtue and talents, unequalled among any other people. But how painful the reflection, in drawing a contrast between this great and magnanimous people, and the present degraded possessors of that delightful country, with whom sloth, superstition, ignorance, and a cowardly disposition, have taken place of active pursuits, liberality of sentiment, and the highest improvements of scientific knowledge. In the manners of the former, we are presented with a most forcible illustration of the happy influence of a free political institution over the minds of men occupying a climate where the comforts and luxuries of life can be procured with but moderate exertion ; while the condition of the others holds up an affecting picture of the baneful effects of despotism over the faculties of men possessing the same natural advantages. But the inhabitants both of Greece and of Italy disagree more remarkably from their forefathers in regard to the mental faculties, that in their personal appearance; as the influence of climate, wherever it is not counteracted by the operation of other powerful causes, must continue unabated. Accordingly, the predominant passions by which these nations are distinguished at present, are equally the effects of climate as the characters of the former people; these being controlled and erased by the effects of oppression, are naturally succeeded by a disposition marked by passions directly contrary.

The ancient Spaniards, in the time of the Roman republic, and long after its downfal, were celebrated for their bravery; and they seem to have made a considerable progress in literary pursuits, and probably in the cultivation of every branch of science. Even in the fifteenth and sixteenth centuries, the Spaniards continued to be the most sprightly and the most polite nation in the world. At the present æra, from causes totally independent of the temperature of their climate, they have become the most grave, and perhaps the most inactive people in Europe. The followers of Mahomet, the Arabs, and the Moors of Africa, may be adduced in proof that an high temperature of the air is by no means unfriendly to the most active pursuits, either corporeal or mental.

The ancient Egyptians and Chaldeans, and others living in countries in the immediate vicinity of the tropics, were brave, active, and warlike. By the indefatigable exertion of their mental faculties, and their laborious application in examining the appearances of nature, the study of science is said to have originated among them. We shall take the following observation respecting this opinion from Paræus' preface to his works, an author, whose sagacity and correctness of observation stand unimpeached. "Æthiopes, Ægyptii, Hebræi, Phenices, Persæ, Assyrii, et Indi, scientias multas pulcherrimas adinvenerunt; naturæ mysteria et secreta revalerunt; mathemata in ordinem digesserunt, motus cœli observarunt, primique deorum cultum, et religiosa sacra introduxerunt." But whether these sciences have originated with those nations or not, we may certainly conclude, that people employing themselves in such researches, ought not to be looked upon either as of an apathous or indolent character.

By referring to facts recorded in the Holy Scriptures, respecting certain classes of people, we have no reason to consider the inhabitants of Asia, even in the most remote ages, as being then immersed in indolence and inactivity; on the contrary, the Jews at every period seem to have been a bustling, intriguing people; their wars and commercial spirit show, that they likewise possessed courage and enterprise. On the other hand, the power of the Canaanites, their different settlements on the shores of the Mediterranean Sea, their maritime discoveries, extensive commerce, and spirited resistance to the tyranny of Alexander, are all convincing proofs, that they must have enjoyed the most respectable faculties of the mind in a very high state of improvement. There are likewise undeniable documents, which show the astonishing progress made by the Chinese, and the inhabitants of India, in scientific improvements, in the most remote ages; which, together with the known elegance of their manufactures, and the extent of their commerce in the earliest periods of historical record, are facts which bear a confirmation of the same opinion respecting them.

The natives of the Moluccas, Ceylon, and others inhabiting the islands of the Indian and Pacific Oceans, as also the different tribes possessing the eastern coasts of Asia, and the interior of Africa, &c. afford, in their manners, a decided proof against the general opinion, that a warm climate enervates the mental or corporeal faculties: even the females of Hindostan give astonishing proofs of the reverse, in the very superior fortitude and resolution of mind, to which their frequent voluntary immolations bear awful witness. The native Americans inhabiting the tropical climates of that continent, were not found dissolved in indolence and sloth, by the invaders of their country; on the contrary, they shewed themselves possessed, in an high degree, of the most noble faculties of man in his most improved condition: they were brave, patriotic, loyal to their king, and faithful to their religious institutions; and contested every inch of their beloved country with a degree of bravery that has never been surpassed on any other occasion; and they could only be made to yield, with the complete ruin of their country, and to the superior ingenuity of European refinement and education: but in point of activity, or in warlike disposition, they did not appear inferior to "the best tried troops of Europe."

But wherever the political government of a country is inimical to personal freedom, in which the necessaries and conveniences of life can be obtained with but little exertion, there men will consequently become apathous and indolent; on the contrary, people living in climates where their natural wants can only be supplied by much exertion and labour, become jealous of every attempt to circumscribe their rights, or whatever has a tendency to prevent the exercise of their faculties, in the way that is of most advantage to themselves. In this point of view, the high temperature of a climate may be said to have an indirect effect in blunting the faculties of the mind, while that of a cold country will tend to rouse them; but from the foregoing observations we cannot discover how it should have such an influence in any other way.

From these remarks it will likewise be better understood, why despotism, so destructive in general to mankind, operates in a peculiarly baneful manner upon the inhabitants of a cold country.

In the preface of Dr Falconer's excellent work on Climate, &c. though he does not admit the above opinion, his ideas being similar to those of Montesquieu on this subject, he seems nevertheless to sanction the theory we have advanced, by the following sentence: "Thus, a hot climate naturally renders man timid and slothful; but the necessity induced by a barren country, number of inhabitants, animal diet, and a savage way of life, may any of them correct this tendency of the climate, and dispose the manners to a different turn." Hippocrates has also attempted to account for the difference of character between the inhabitants of Europe and Asia, upon nearly the same grounds, in his book *De Aëre, Aquis et Locis*, xl.: after having premised some remarks on the spontaneous fertility of the climate of Asia, he says, "Ubi autem non in sua potestate vivunt homines, neque sui juris sunt, sed dominis subjecti, ibi non multum curiosi sunt quo modo se ad bellum apparent, immo magis hic curant, ut ne bellicosi videantur, pericula enim eis non equalia instant. Nam hi in militiam proficisci laboresque perferre, ac mortem oppetere pro dominis suis coguntur, relictis interim domi liberis, uxoribus ac reliquis amicis. Atque siquidem viriliter et feliciter bellum gesserint, dominis inde commoda accedunt, eorumque facultates inde augentur; verum ipsis præter pericula et cædes nihil demetitur." And in liv. of the same book, he continues, " Quare etiam magnanimos magis eos, qui Europam incolunt, Asianis judico. Siquidem similitudo et æqualitas temporum segnitiem parit. Mutatio autem et animum et corpus ad exercitationem excitat. Augetur itaque a desidia et ocio timiditas, ab exercitio vero et laboribus crescit virilitas, unde bellicosiores quoque Europæi extant, non ob hanc solum causam, sed et propter leges, non enim regibus obediunt quemadmodum Asiani. Ubi enim sub regibus, ibi necesse est homines timidissimos esse. Servitute namque animi eorum pressi non libenter, neque volentes temere pro aliis se periculis exponunt. Europæi autem suo jure viventes, quum pro seipsis pericula belli subeant, magna cupiditate feruntur, volentesque ac alacres difficultates omnes agrediuntur, ipsique sibi ex re bene gesta præmia reportant, ut certum sit leges plurimum ad magnanimitatem conferre."

The effects of the continued application of an high temperature of the atmosphere, when much bodily or mental exertion is required, will certainly prove extremely oppressive to those unaccustomed to it, and especially if they persist in the same sort of diet and clothing, which is better suited for the inhabitants of a colder or more temperate country; but when no additional stimulant effects are imparted to the system, by the use of an improper mode of diet, or other circumstances, considering the considerable diminution of the pressure, in an high temperature of the atmosphere, we are persuaded, that in this manner the effects of its stimulant operation are perhaps nearly compensated, and cannot be sensibly felt by the natives, or those who have lived for some time in such a climate.

There is a sprightliness of character, and a luxuriancy of imagination, peculiar to men inhabiting a warm climate, which probably increases in approaching the tropics. The grandeur and sublimity of expression of eastern nations, have been the subject of admiration in every age. The elegance and freedom of manners of certain people of warm climates, and the lively disposition of those tribes who are not under the necessity of submitting to the rod of tyranny, either religious or political, have given rise to descriptions of manners, more romantic and sublime, than are to be met with in any other language. The French have a predominant character at present, in these respects, above every other European nation; but there is the written evidence of former times to convince us, that the neighbouring nations of Italy and Spain excelled them in liveliness of manners, before the introduction of certain religious customs amongst them: and since that period, these people have gradually become so grave, that the Spaniards of the present day are not exceeded in sedateness of deportment, by the most phlegmatic nations of the most northerly climates. Taking all these circumstances under review, it must appear, that the commonly supposed effects of an high temperature of the atmosphere on the active powers, has no direct influence in abating their energy; on the contrary, from the facts we have adduced, it seems rather probable, that in a free religious and political state, the warmth of a climate tends to quicken the faculties, and to render them more energetic: indeed, without these advantages, man will become indolent in every country, and that too in the greatest degree where the medium temperature of the air is lowest.

We have seen, that the effect of indolence in debilitating the mind, was long ago remarked by Hippocrates; and we have daily experience to convince us of the correctness of the observation, that idleness and leisure increase and favour a cowardly disposition, but that manly courage is the produce of labour and exercise.

From the effects of heat in diminishing the gravity of the atmosphere, we are enabled to comprehend, why the corporeal and mental faculties suffer less in a warm state of the air; its gravity, by this means, being proportionally lessened, and its elasticity increasing according to the proportion of free caloric with which it combines. We therefore find, that under a temperate and serene sky, man is more active, and performs the functions of his body with greater facility and vigour, and at the same time he enjoys an higher degree of mental energy; he is, upon the whole, more healthy and fitter for procreating the race: but in a dull, cloudy, or wet condition of the atmosphere, the body is extremely apt to fall into a lazy state; the mind becomes dejected and melancholy, with a corresponding decay of every desire for activity or exertion. These conditions take place, not merely in a continued state of the atmosphere, constituting a permanent peculiarity of climate, but they are likewise observed to happen upon every incidental change of weather.

The greater heat of a climate seems to add likewise to the natural ferocity of wild animals; and tropical countries are therefore found to give birth to such as are most untamable and savage. The variety and virulence of the venom of poisonous creatures, seem to be heightened by the operation of the same cause: on the other hand, the ferocity and venomous nature of different species of animals lessen, and the number of these even becomes more scarce, in approximating the higher latitudes towards the pole.

Having finished our remarks respecting the influence of climate in varying the dispositions and faculties of mankind, in different countries, and having confined these observations to that range within which the functions of the system are performed in a healthy state, we next proceed to investigate its influence, when its operation upon the system induces changes in its functions, totally different from those which constitute its former condition.

Very high and very low degrees of atmospherical temperature are said to produce similar effects upon animals; and innumerable instances of their pernicious influence upon man may be seen in different professional treatises, books of travels, &c. However, we must be cautious in considering the nature of diseases arising from these causes as being similar; as extremes of temperature have not, by any means, the same effects upon the constitution; those diseases which originate from deprivation of heat, being evidently the consequence of debility, from the undue abstraction of a stimulus necessary to health: the others, on attentive examination, will be found to be characterized by marks of increased excitement, in consequence of the unnatural accumulation of a fluid of the highest stimulant powers. But the health of man is most certainly injured, by sudden alternations of temperature; an equality of climate, whether it be high or low, being most friendly to the constitution. Owing to this cause the Egyptians were remarked by Herodotus to be more healthy than the neighbouring nations of Syria and Lybia: "Aëris beneficio qui nunquam mutatur, ex quibus immutationibus præcipue existunt in hominibus morbi." This is the description this author gives of that climate, which is found to be pretty similar at the present time, and would be equally salubrious, were its present inhabitants equally refined, and enjoyed the same judicious form of internal police.

Hippocrates seems to have bestowed much attention in investigating the power of the atmosphere upon mankind, and the reference which we have formerly quoted from his works, shews how judiciously he has pursued this study, and his judgment in separating the effects of other causes, which modern authors less attentively have confounded with those which are clearly owing to the influence of climate.

"Aër," says he, "est omnium rex morborumque causa:" in another place of his writings, he says it operates upon the body, "a calido supra modum calefaciente, a frigido supra modum refrigerante, a sicco plus æquo resiccante, et humido etiam plus æquo humectante;" which order we shall follow, in a certain degree, in the view we are about to take of the subject. There is certainly no circumstance more important, than in being capable of distinguishing those diseases which arise from the influence of climate solely, from others, which owe their appearance to the operations of certain causes depending on situation, as the water, diet, &c. and which in their effects are too often blended with the former.

A low temperature of the atmosphere, alternating with great heat, has been found to produce fevers of the inflammatory kind, catarrhus, pleuritis, rheumatism, apoplexy, inflammations, mortification, and phthisis. It would appear, that surgeons in former times were always extremely cautious in examining the state of the weather, previous to attempting any important operation, as many unfavourable occurrences had happened in the after management of their patients, which, with seeming justice, have been imputed to this cause. Summer, and the end of autumn, were from experience esteemed the most improper seasons for operative surgery.

There is a fact related by Rawlin, which happened in 1718, in the Hôpital de la Charité, at Paris; thirty patients having submitted to the operation for the stone, of whom twelve died, and their deaths were imputed to the occurrence of a severe thunder-storm, which commenced soon after they had been cut.

The diseases which are owing to a low temperature of the atmosphere, except those where the effects are entirely local, seemingly arise in consequence of a diminished perspiration; they differ in variety, according to the constitution of the person exposed to its influence, its degree of force, and the susceptibility of the organ most exposed. From what has been premised on the cause of evaporation, it will be readily understood, that a low temperature of the atmosphere must be but rarely combined with much humidity: in instances where this peculiar constitution of the air has been supposed to occur, it has been said to produce the most debilitating effects on living bodies, and to be more pernicious than merely a cold dry temperature of it; it obstructs perspiration in a greater degree, and relaxes the system: and by being imbibed through the skin, it impedes the force of the circulation; in this way, it disposes to dropsy, occasioning visceral obstructions and mental diseases. It likewise acts by occasioning rheumatism, spasm, and other ailments;

the consequence of the diminished temperature of the system, by the evaporation of the humid atmosphere from the surface of the body. It is owing to the prevalence of particular states of the weather in certain situations, that acute endemial diseases are generated every where; and it is to the fluctuating and mutable condition of the climate of the British isles, that the frequency of phthisis among their inhabitants has been justly imputed. There is a circumstance that merits consideration in investigating the causes of the chronic endemial diseases of any country; the brute creation having in every situation been found exempt, in a great measure, from diseases which have been supposed owing to the influence of particular states of the atmosphere,—a circumstance, which affords some reason to suppose, that such disorders among men must be owing in a certain degree to other causes. However, in Britain, disorders resembling phthisis and scrofula also, are frequently met with amongst domestic animals, and are no doubt occasioned by similar causes to those which induce corresponding disorders amongst the human race; though, it is also to be remarked, that the former are much less liable to disease of any kind than man, and with whom this disposition seems to increase, with the degree of civilization and mental improvement.

When treating of respiration, we mentioned the intimate connection that subsists between the skin and respiratory organs, the purposes of these functions being in many respects similar; as the excretion of a fluid, which, by accumulating in the system, would occasion the most fatal consequences, depends upon the healthy state of these organs.

The quantity of matter discharged from the surface of a middle-sized man in these climates, has been supposed to amount on an average to about twenty-four ounces daily; in this calculation, the proportion excreted from the lungs is included: these particular offices of the lungs and cuticular organs frequently alternate with each other in a certain degree; the proportion discharged from the lungs becoming greater, when any temporary cause exists to lessen the discharge from the skin, and *vice versa.*

Phthisis is most commonly met with in a variable climate, where sudden alternations of temperature supervene during every season of the year. Such is the climate of Britain, where the weather is at all times extremely variable, with rather a low medium temperature of it.

In this climate, the cuticular discharge cannot therefore be so great as even in the inhabitants of parallel latitudes on the continent, where the climate is not so liable to be affected by sudden variations of temperature; and the quantity discharged is found to be much less than in men living in climates nearer to the equator. From this cause, an increased determination of blood to the lungs likewise takes place, this being the natural consequence of whatever diminishes or obstructs the cuticular discharge. The determination of blood to the pulmonary system, and the force of the circulation also, are probably excited in a greater degree by the alternate impression of an atmosphere of a warm temperature suddenly occupying the place of that which has been cooled to a very low degree, thereby increasing the sensibility of the lungs in a proportion corresponding to its diminution of temperature. In this manner, we suppose catarrh, inflammation, hæmoptysis, tubercules, phthisis, and catarrhus senilis, are produced, according to the degree of impression from the exciting cause, and the susceptibility of the system.

It is fully ascertained, that the permanent existence of any particular cause, which has the power of influencing the habits, frequently induces a variation in the form of the body; therefore, when it ceases to act, its effects continue equally strong, and are frequently transmitted as peculiarities in the functions of succeeding generations. This appears to receive illustration in the instance now under our consideration. In the case of phthisis, we conceive, that an hereditary susceptibility of similar impressions is regularly transmitted from father to son, and that the consequences of this are increased, by the continued operation of the causes by which this bias was originally acquired, and in this way the peculiar form of the thorax of phthisical people is produced. It is for these reasons alone, we suppose an hereditary disposition to phthisis does exist in certain constitutions, and why it also frequently occurs from the direct influence of the mutability of the climate, in cases where no hereditary taint can be traced. Consumptions are now much more frequent than in former times, every where in Britain. We have a very striking instance of this effect, in the change of prevailing disorders which have occurred of late years, in the county of Berwick, where, about thirty or forty years ago, intermittents were extremely common, and cases of consumption were rarely met with: however, for these many years past, agues have almost completely disappeared, and phthisis has now become so common, that it is certainly found to be the most prevalent chronic disease of that part of the country. This change has evidently succeeded in consequence of an alteration in the atmosphere over that district. About the time we have specified, the soil lay unimproved, and intersected with marshes; of course, its atmosphere must have then contained a greater proportion of vapour at every season: but within this period, the operations of agriculture have been carried to a greater state of improvement than is perhaps to be seen in any other part of the island: its atmosphere, on that account, must have become drier. Nevertheless, with this meliorated condition of the air, consumptions have gradually increased: but it is not certainly to this altered condition of the climate of that county, that this particular disease is to be imputed; its cause can with more reason be ascribed to the bleak cold weather, which has been so prevalent in our springs of late years, and which, from the foregoing reasons, must have a considerable influence in rendering pulmonary complaints more frequent every where. Although the range of the thermometer may be greater in more northerly countries, where phthisis does not so frequently occur, we consider this exemption as entirely owing to the constancy of the same sort of weather during the different seasons of the year. In Russia, for instance, the cold weather lasts through the winter without intermission; and although it is succeeded by warm weather without almost any intervening spring, yet the temperature of the atmosphere during both seasons continues uniform throughout the respective periods, without suffering those sudden alternations to which the climate of Britain, from its insular situation, is so liable. Neither is phthisis so frequent in a damp cold climate, as in Holland, nor in any country where the state of the weather through the different seasons of the year is not variable, at whatever degree the temperature may be. These are the causes which appear to give origin to the frequent consumptions in this country, and which is in much greater proportion than among the inhabitants of any other climate. No doubt, these affecting peculiar constitutions, will give an apparent variety to the disease; and it seems in consequence of the more acute susceptibility of people of a scrofulous habit to the variations of the atmosphere, that phthisis is most frequently met with in them.

Scrofula is evidently a disease totally distinct from a phthisical constitution, though they are frequently met with in the same person. The latter, we have endeavoured to show, is most commonly a disorder incident to certain climates: we shall afterwards find, however, that the former, though usually imputed to similar causes, can be more satisfactorily accounted for, as originating from sources entirely unconnected with any condition of the atmosphere, and which we shall proceed to investigate, when we come to treat of goitre and cretanism.

A continued application of an unusually warm atmosphere, is commonly supposed to induce complaints of debility, as languid motion, herpetic and leprous eruptions on the skin, ophthalmia, and visceral obstructions. All these complaints in this way arise from over-excitement, the usual effects of a long exposure to a hot climate. Dr Chisholm remarks, that he always observed, that new comers from Europe to the West Indies have a greater heat on the surface of their bodies than the natives, or those inured to the climate.

It is principally owing to the stimulating or debilitating effects of the high or low temperature of a climate, that endemial chronic complaints are generally occasioned. But a high degree of heat in the atmosphere, over a situation where there is a considerable extent of stagnant water, and especially if it abounds with the putrefying remains of animal and vegetable matters, always produces acute diseases of the most malignant description, as intermittents, remittents, typhus in all its varieties, and apoplexy; and, as will be afterwards more distinctly pointed out, probably disorders even resembling the plague itself have their origin from the co-operation of such causes. A warm air, loaded with watery vapour in a pure state, is observed to produce the most debilitating effects on the living body. In such a condition of the air, the habit is increased in bulk, the blood-vessels appear more distinct and turgid; the skin is however pale, the face somewhat inflated, with a peculiar dulness of the features, and a slothful disposition.

A warm atmosphere, impregnated with humidity, and in situations where its free circulation is impeded, as in particular districts of mountainous countries, or in low marshy places, as in the Lagunes of the Venetian territories, and even in certain of the Dutch provinces, has been alleged to engender a disease of the thyroid gland, called goitre. But it is to be observed, that although this condition of the air may tend to influence the system in a considerable degree, it does not readily appear how this general cause should affect any particular organ not immediately exposed to its power, and that too uniformly and without exception. On considering this objection, pathologists have assigned other causes for this disease, which are also connected with our present investigation. Dr Moseley imagines, that goitre is occasioned by a too free exposure of the neck to the vicissitudes of the weather, and thence it is so common amongst women and children: but were it owing to this cause alone, it would be almost entirely confined to the female sex; and we should in that case find the British fair equally affected with it, as the inhabitants of certain districts of the Alps.

The use of snow-water has been also brought forward as the noxious agent in this case; but it is observed, that goitre appears in its most shocking varieties in situations where this water is not employed, being frequently met with in the low grounds of the mildest climates;

and on the other hand, it is not observed to prevail in those countries where no other water than that procured from melted snow can be used for the greatest part of the year. Besides, snow-water is generally very pure, and perhaps never contains, in its ordinary state, extraneous matters in sufficient quantities to occasion this, or any other disease.

There are many reasons to induce us to regard the goitre as a particular variety of scrofula: in this country it is only seen in highly scrofulous constitutions. Rickets are observed to be frequent in every country where the goitre is endemial; and it is generally admitted to have an intimate connection with scrofula. At the same time, there are other marks of this disease amongst the same people, which all probably depend for their origin on the action of the same causes. Wherever the goitre has been discovered, in the Alps, Tyrol, Abyssinia, and in the vicinity of the Chinese Wall, the water in general use has been uniformly found to contain a quantity of selenitic matters; and it is more probably owing to this cause that scrofula is so common in the British isles, than as being occasioned by any peculiarity in the surrounding atmosphere, which is continually varying and changing its place. Pallas says he perceived the goitre very frequent about Axaa in Siberia, where the water is "un peu ferrugineux, et chargé de molecules marneuses." In every situation that we have had occasion to observe scrofula more frequent, or in a more aggravated form than usual, this condition of the water has been uniformly remarked. At the town of Rheims in France, while its inhabitants were supplied with pump-water only, which contained a considerable portion of lime, scrofula prevailed so generally, that they were under the necessity of instituting an hospital expressly for those ill of that disease. Some time after, when the town was supplied with water from an adjoining river, which contains no selenitic matters, scrofulous disorders decreased so rapidly, that in a short time the trustees were enabled to appropriate the funds of the hospital to other charitable purposes.

At Aracana in the East Indies, where goitre prevails to a great degree, though the currents of water run rapidly, yet they taste heavily and disagreeable, and the fish they contain are insipid and not good. In Derbyshire, Valteline, Fribourg, Berne, Pay de Vaux, the neighbourhood of Dresden, Savoy and Piedmont, the waters are considerably impregnated with lime.

A surgeon, whom Mr Cox met with at the Baths of Leuk, told him that he had extracted chalk-stones from the goitrous swellings: he likewise assured Mr Cox, that one of his own children was born with a goitrous swelling on his neck; and that foreigners are rarely affected with this complaint by living in situations where it is common, though there are some instances of their having acquired it in this way. This, however, we must remark, is expressly contrary to the opinion of the celebrated Hoffman, who says he has found the necks of strangers become tumefied to an enormous degree, by living in such situations even for a very few years. The following observation by Gmellin on this subject, coincides exactly with the above, and in other respects is valuable, as affording a convincing proof that animals are also liable to certain chronic endemial diseases, similar to those which affect man living in the same situations. "Les habitans de ce district des bords de Lena, hommes et animaux, comme les bœufs, les vaches, &c. sont sujets aux goitres; j'en ai vu qui n'en cedoient point aux goitres les plus respectables de la Suisse, et de quelques endroits d'Allemagne. C'est même ici que l'on pourroit dire, avec plus de droit qu'en aucun autre lieu de monde, qu'un homme n'est censé bien complet, que quand il a un bon goitre. Voudroit-on en rejetter la cause sur les montagnes? Les vaches n'y vont point, et les femmes ne se mêlent d'aucun ouvrage hors de maison; ainsi leurs goitres ne proviennent point des efforts qu'elles font pour grimper les montagnes. Un jeune homme, pourvu d'un goitre aussi bien conditioné qu'il y en eut, me racontoit, qu'ayant passé une année entiere dans les environs de la riviere d'Auga, son goitre, pendant ce sejour, c'étoit considerablement diminué; mais qu'il avoit réprit son volume quelque tems apres son retour dans le district de Karenga. On croit ici communement, que les goitres sont hereditaires, et que les enfants naissent avec ces sortes des excroissances, ou du moins en apportent le germe; mais ce sentiment n'est pas général; il n'est pas adopté sur tout par ceux qui ont des goitres, et qui cherchent à se marier."—See vol. xviii. of Prevost's General History of Voyages, p. 259. Mr Cox was told, that the most effectual cure was obtained by removing to a place where the water is pure.

Hoffman remarks, in his Treatise on Endemic Diseases, that in the district of Flach in the Tyrol, there is a fountain whose waters produce this disease by drinking them, and are thence called the Scrofulous Well, or Kropff Brunn, in the language of the country; and for the cure of the goitre he recommends a removal from the situation where it has been contracted. Sir Richard Clayton, in the 3d vol. of the Manchester Memoirs, gives a very interesting paper on cretenism, which he seems to think, with Saussure, is owing to the warm moist atmosphere which is usually observed in the Alpine districts, where this disease prevails; that the goitre is different, and is probably occasioned by water impregnated with earthy or metallic matters. The former he compares to the Dondos or White Africans, the Chacrelas of

Asia, and the Blafard of the isthmus of Darien, which have a considerable resemblance to each other, and equally betray a debility of organization. But, considering the observations adduced by Mr Cox, and by Sir George Staunton in his Account of the Embassy to China, we are inclined to regard the goitre and cretenism as gradations of the same disease, or that the former becomes frequently the cause of the latter, goitrous parents being observed to produce cretin children.

The nature of this work does not admit of a more full discussion of this particular subject. However, we have endeavoured to show the improbability of goitre being occasioned by a peculiar state of the atmosphere; and though we may perhaps have failed in assigning its specific cause, the facts we have collected render it very probable, that it depends on some peculiar condition of the water, or circumstances unconnected with climate. Indeed, in the natural effects of climate in general, there is always the co-operation of other causes which increases its power.

Rickets, notwithstanding the variety of causes to which it has been imputed by the most celebrated physicians, seems, according to general observation, to depend oftener on an impure state of the atmosphere; and in these circumstances, it has been found to take place in its worst forms in children, where there is no apparent constitutional predisposition from scrofula, or from the effects of any other constitutional disease.

It is difficult, or perhaps impossible, in the present state of our knowledge, to point out the precise state of the atmosphere inducing this disease : it is a condition of it, where a variety of extraneous exhalations predominate, and where aqueous vapour, mixed with the discharges from the functions, more particularly abounds, with a low temperature of the climate : in short, it is that condition of the atmosphere, which is found in houses placed in ill ventilated streets of crowded cities. It is perhaps owing to the variety of extraneous exhalations at all times existing in the air of cities, even those the most favourably circumstanced, that their inhabitants are commonly of a paler complexion, of a more feeble frame of body, and possessed of less intrepidity of character, than those inhabiting the country. The constant respiration of an atmosphere loaded with an undue proportion of carbonic acid gas, will certainly conspire to those effects : in this way we find, that chronic diseases originating from the inhalation of impure air, are rarely met with in the inhabitants of the country, or in the quarters of a city where attention is paid to cleanliness without, and propriety in the domestic management. From these facts, we are confirmed in opinion, that the proximate cause of rickets consists in an irregular and depraved state of the functions of assimilation, and is so far a disease of climate.

The application of matters at a low temperature, as vine leaves dipt in cold water, and cold water itself, was strenuously inculcated by physicians at a very early period, as a remedy essential for the cure of several febrile disorders. This practice was likewise followed by many celebrated men, even in the middle ages. Chardin, in his Travels in Persia, found, that immersion in cold water was a common practice at Tiflis in Georgia, and other places of that country, during the hot stage of ardent fever: this remedy had been disused in Europe for several centuries, and has only been revived in the present times, and has received the sanction of physicians of high reputation for experience and scientific knowledge. But the merit belongs to Sydenham alone, for the beneficial effects that accrue from the free admission of cool air into the apartments of the sick; and it is probably owing to this practice, in a great degree, that epidemical diseases, especially the plague, are less common in Britain, since the period in which he lived. There is not perhaps any acute disease to which mankind is liable, where the admission of the atmosphere, at a moderate temperature above the freezing point, would not be attended with advantage; and there are many complaints where it would be of the highest utility, even when under 32°. In the relation Dr Blane gives of the hurricane at Barbadoes in 1780, he mentions the case of a lady ill of pleurisy, who was exposed to the cold wet atmosphere for ten hours, at the end of which time she found herself completely free of the disease : and many similar facts are related by Dr Beddoes. Indeed, the method of treating pleuritis, by obstructing the admission of a cool atmosphere to those labouring under this disorder, seems the result of a prejudice, not very creditable to physicians, and which is certainly refuted by the success that attended an opposite practice in the above-mentioned cases. Cold applications may be considered as useful in the incipient stage of every inflammation that is not esteemed critical; and they have been lately recommended in a very earnest manner, as a cure for the gout and rheumatism. But we confess ourselves too little acquainted with the influence of the causes directly exciting those complaints, to give a decided opinion on the probable good effects of their use: we shall therefore quote the opinion of Dr Gregory, in opposition to the doctrine on this subject, an authority of at least equal respectability. Accordingly, in his work, *De Morbis Mutatione Cœli Medendis*, he says, with regard to gout: " Constat etiam subitam corporis refrigerationem, paroxysmum arthriticam haud raro inducere. Et sæpe arthritici a pedum refrigeratione aliqua, leves dolores podagricas sentiunt;" and in the same work, several instances are given, where the disease was seemingly cured by the general effect of a hot temperature of the climate. Hoffman likewise mentions a district in Upper Germany, where, though the gout is prevalent all round, yet its inhabitants remain free from it by the use of warm diluents keeping the pores open. Still the favourers of an opposite practice may fortify their opinion from what Hippocrates says on the subject.

Cold sea-bathing, as a stimulant, has been found of the highest utility in stopping the progress of the gout, when employed with other parts of a general ant-arthritic regimen; and the same remedy has been generally employed successfully in chronic rheumatism, and for counteracting the debility its repeated acute paroxysms frequently induce; in this complaint likewise, it has been supposed to possess preventive powers.

But, although the good effects of cold air is experienced to be of the highest utility, in the cure of acute disorders, a warm temperature of the atmosphere is found to be of equal advantage in several ailments of the chronic kind, and even in warding off attacks of many diseases of the other class. Emigration to a climate whose temperature is mild and equable throughout the year, has been therefore recommended to valetudinarians, from whatever cause their ailments may have arisen.

The European climates, best suited for people become infirm, or labouring under any specific complaint, occasioned by living in countries less genial and warm, are the champaign countries of Spain and Portugal, Italy, Greece, the south of France, and Madeira, and Summer Islands lying in the Atlantic Ocean. The West Indies has also been recommended for those labouring under phthisis. There are diseases frequently met with in colder latitudes, which rarely appear in warm countries, and, for their cure, a genial temperature of the atmosphere has been found to be the most effectual remedy. Rheumatism is not a frequent complaint in a warm country, and is rarer in cold climates during summer; when this disease originates from an irregular or suppressed perspiration, its attacks may always be prevented, and even its debilitating effects are generally completely cured by removing for some time to a warmer climate. Many diseases arise from the same cause, and appear in obstructions of the thoracic or abdominal viscera, or in an unusual determination of blood to some internal organ, as the lungs, head, uterus, &c.; and in all such cases, a steady warm atmosphere has been found to have the most beneficial effects: this is in consequence of the increase and uniformity of the cuticular discharge, thereby keeping up a continued determination to the skin. It has been supposed, that in this way, gout, dyspepsia, hypochondriasis, asthma, but especially phthisis pulmonalis, have been generally relieved, and in many instances cured, by emigrating to such a situation. And cephalœa or headach, when its cause depends on an increased determination to the head, and when no organic lesion exists, or in consequence of sympathy with the stomach, or some other organ, has been found to be cured by the same means. But people resorting to a foreign climate, for the cure of any complaint, must consider, that it is only by the permanent operation of its power that the disease can be completely eradicated, and their stay will be therefore necessary, even for a considerable time after all symptoms of the disease have disappeared. But in no case is this caution so necessary, as to those affected with consumption. There are daily instances of people affected with this disease having remained in the warmer climates of Europe till they had apparently got rid of every appearance of the complaint, and, by returning at this period of their cure, very soon after have fallen victims to its renewed attacks. On the other hand, there are many instances of people who in this country were affected with the most decided pulmonary consumption. In some, it seemed to arise from an hereditary tendency to phthisis; in one case it arose from improper management in a severe attack of pleuritis: but, by living in a warm climate these several years past, they have not even once been threatened with a returning symptom of their complaints, though they had all been affected, previous to their leaving this country, with purulent expectoration, hæmoptysis, and hectic fever. The last who went out has been absent these four years. They all seem inclined to remain some time longer; and it is very probable, that in the period of a few years more, the peculiar disposition to the disease may be so far overcome, as that they shall be able to revisit their native country, with perfect security against a relapse.

The good effects of an equally warm atmosphere in diseases of the breast, operate principally in the manner we have already stated; but it is not improbable, that a more rarefied atmosphere of a genial temperature, by causing less irritation, either by its gravity, or from any other cause, will also prove of the highest service in this way. Phthisis is not unfrequent in every country; but in warm latitudes this disease is much less common. We have the authority of Dr Moseley to assure us, that phthisis, calculus, and scurvy, are very rare complaints in the West Indies; but it is not to be understood therefrom, that living in a warm climate, possessing nearly an equal degree of temperature throughout the year, that every consumption is to be got rid of: this is by no means the case. Besides, a great proportion of phthisical people only resort to those climates after the disease has committed such ravages in the constitution, that no natural means are equal to perform a cure; and consumption likewise frequently arises from other causes, which are not to be counteracted by this remedy alone. Dr Gregory therefore limits the trial of a warm climate to phthisis originating from tubercles, pneumonia, and hæmoptysis; these being the cases in which its effects are most beneficial. But, from what has been said on the general effects of heat, it appears, that change of climate ought not to be restricted to phthisis arising from any particular cause, as it will always operate, with other means, as a powerful auxiliary in performing a cure.

A warm climate is also of the greatest service in removing asthma, catarrhus senilis, and other pulmonary affections; and for the incidental complaints common to old age, it is certainly the most useful remedy; it having been found the most effectual means of warding off the most distressing consequences of advanced life. Its operation in this case is similar to that of its effects in general: these have been fully discussed as a medical subject, in Dr Gregory's treatise above mentioned, a work which in many respects merits a careful perusal.

In the effects of climate, light performs a most important part; and its influence, although not so well understood as that of heat, is perhaps not less powerful in modifying its impression. Light acts upon the animal and vegetable tribes as a stimulant of a very powerful kind; and it is probable, that in the circumstances we now consider it, this property of heat is considerably augmented by its co-operation; for it is to be kept in view, that the intensity of the luminous matter is generally in proportion to the temperature of the climate, these arising from the same source. Its importance in the process of vegetation has been already shown; and it seems in a great measure owing to its power, that vegetable productions are so much more plentiful, and of superior qualities, in meridional climates, to what they are found to be in latitudes approaching the poles; and it seems to be principally owing to the want of the benignant influence of the luminous portion of the sun's rays, that melancholy and other torpid affections of the mind are more prevalent in such situations. When there is an insufficiency of light, plants never prepare juices of a proper quality, and their seeds are never so productive. A similar effect is probably the consequence in the animal creation; the individuals of both tribes being puny, deformed, scarce, and of fewer varieties. The influence of light on the state of the mind, we have already mentioned.

and also its effects in varying the colour of animal and vegetable matters ; but, in almost every instance, its influence is so intimately connected with that of heat, that, in their power of modifying climate, they are scarcely separable ; therefore, great part of what has been advanced on the influence of the temperature of the atmosphere, may be considered as involving the effects of light at the same time. The power of variations in the states of density of the atmosphere over the animal and vegetable kingdoms, cannot be separated in its effects from that of temperature ; though its influence will be readily admitted, by reflecting on the very immense load with which the atmosphere presses upon our bodies, and of the frequent accumulations and diminution of this pressure, as indicated by the barometer. This is more particularly perceived in its influence over the mind ; the faculties being dull and oppressed in cold weather, and in every condition of the atmosphere where the barometer stands high : and it seems evidently owing to this cause, that apoplexy and pulmonary complaints are more frequent in climates of a variable temperature. When the barometer stands low, the mind is cheerful and elastic, and all the corporeal and mental faculties are exerted more perfectly in this state of the weather ; the circulation on the surface is greater, the perspiration more, the secretions being thereby diminished : it is therefore probably owing in a great measure to this circumstance, that obstructions in the abdominal viscera take place most frequently in those climates where this state of the weather commonly prevails, as in countries within the tropics.

SECT. III.

OF THE INFLUENCE OF VARIATIONS OF THE HUMIDITY OF THE ATMOSPHERE ON ANIMALS AND PLANTS.

A DEFINITE proportion of humidity in the atmosphere, is probably necessary for the regular performance of the functions of the animal and vegetable economy; an excess or diminution of this stated quantity, causing them to languish, to become diseased, and decay. It seems almost impossible to determine the precise quantity of moisture necessary for each individual species; but when the atmosphere contains an excess of humidity for some time, animals do not seem to be so immediately affected by it as plants in general. Some vegetables only thrive when wholly immersed in water, and are thence named aquatic plants, and which are found equally common, and in the same varieties, in every climate, as water cresses, water parsnip, and many others; the temperature of springs in which they grow, being nearly the same at the pole as under the line. There are others, again, which will not grow but in the most arid situations, and seem naturally placed where the moisture necessary for their growth must be entirely acquired from the atmosphere; and even amid the burning sands of the African deserts, plants are found dispersed in a state of vegetation. From this property in some vegetable tribes, of fixing themselves in sandy situations, they have been advantageously planted in places that are liable to shift; by their taking root, a degree of firmness is acquired, that admits of the propagation of other plants, and thus renders the ground stationary: of these, the most remarkable and best fitted for this purpose, is the Arundo phragmetis or common reed grass, the Arundo arenaria or sea reed grass, and the Poa aquatica or meadow reed grass, the Nardus stricta or mat grass, &c. &c. Animals agree with plants in the quantity of humidity that is necessary for them: some only inhabit the torrid zone and the driest situations; others are wholly confined to the water; and a third or intermediate kind, enjoy their faculties in an equal degree either upon land or in the ocean. An uncommonly dry state of the atmosphere, is equally unfriendly to a sound state of health, as an unusually moist condition of it; but either state is entirely modified in its effects, by constitution and habit, both in the vegetable and animal tribes. A very dry state of the atmosphere is frequently of advantage in stopping obstinate diarrhœas, pestilential diseases, and in the healing of old ulcers, &c. as is experienced frequently on the African coast, during the prevalence of the harmattan wind, and in Italy when the scirocco blows. Diseases brought on by a too arid state of the climate, as herpetic eruptions, and ophthalmia, suffer a very favourable change while an opposite condition of the weather takes place. In this way it is found, that the elephantiasis of the Egyptians and of the Asiatics on the shores of the Indian Sea, is most prevalent amongst them, where the situation is most humid, and during the rainy season. As was already observed, diseases peculiar to certain seasons prevail in every climate, but these are equally owing to a change in the temperature of the climate, as to a variation in its state of humidity.

In the climate of Britain, an excess of humidity in the atmosphere is, in most instances, more pernicious to vegetation, especially to those plants which produce bread-corn. In such a state of the air, plants grow tall, producing a greater abundance of leaves, with a crude watery fruit. In this condition corns are extremely apt to become heated when stacked; and the quality of every sort of fruit seems inferior, in a season while such a state of the weather prevails; which is probably owing, in a great measure, to the diminished temperature that always accompanies an unusually moist state of the air.

In the same climate, during a season when the state of the atmosphere is unusually dry, vegetables seldom acquire their natural size; their appearance is rather shrivelled: but if the drought only occurs late in the summer, the quality of the fruits and grains is rarely deteriorated; on the contrary, it is commonly better, though frequently less abundant than in seasons of ordinary condition, either as to heat or moisture.

In the following discussion respecting the insalubrity and innocent effects of aqueous vapours, it is to be kept in mind that we at present consider the humidity of the atmosphere as being pure and unmixed with any extraneous matters.

A very humid state of the atmosphere, and moist situations in general, have been looked upon as unfriendly to every sort of animal, but more particularly to man; nevertheless, the correctness of this opinion is by no means corroborated by observation; and it may be very reasonably questioned, whether a moist state of the air, of short duration, or even a moist situation, in a temperate climate, be ever succeeded by any other bad effects, than what result from an alteration in the temperature of the body occasioned by evaporation. Nevertheless there are diseases in every country, more particularly peculiar to certain situations, where a superabundance of humidity prevails in the atmosphere; but whether these are entirely owing to the existence of humidity alone, it is impossible to say: in the instance of croup, this certainly does not seem to be altogether the case; it is a disease found most frequently to occur, in this country, in situations where the air is apt to be impregnated with vapour from the sea, or where the water is comparatively pure, though nearly stagnant; in this way it is most frequently met with on the sea-coasts, in marshy grounds, and amongst children exposed to the exhalations from canals, lakes, &c. *

Watery vapour, if not excessive in quantity, and continued for a considerable length of time, is by no means inimical to the human frame: probably the very opposite opinion should be entertained of its effects, otherwise nature, so benevolent and so provident in the preservation of her works, would not have exposed her productions so freely to its influence. Dr Arbuthnot, from personal observation and literary research, found, that extraordinary dry seasons were the most dangerous: thus, the year 1714 was extremely unhealthy, evidently from want of a due proportion of humidity in the air. Were watery vapour really pernicious of itself, every maritime situation must have been unhealthy, and summer would have been in that case the most sickly season of the year. It is to be observed, that matters possessing the most noxious qualities, are frequently elevated with aqueous vapour, especially in hot climates, and in this way diseases of the most aggravated malignity are generated. This affords an explanation of the dangerous consequences of being exposed to the dews arising from marshy situations within the tropics, the Campagna di Roma, several places in the vicinity of Naples, the Milanese, in Hungary, &c. Indeed, unhealthy situations, from deleterious exhalations, are found even in the most temperate climates, during the warm season. But in proof that this unhealthy condition of the air is not entirely owing to the water it contains in the state of vapour, it is perceived, that situations on the sea-coast every where enjoy a climate superiorly healthy to those inland; and likewise places on the banks of rivers, where the currents prevent a stagnation of any part of the water, are generally known to be very salutary: nor have we been able to trace any peculiar disease prevailing amongst people inhabiting the most impenetrable clay soil, where the atmosphere must be consequently more humid than that over grounds of a more open texture. Indeed, the general complaints prevailing in such tracts, can be in almost every instance traced to the operation of other local causes.

In addition to these remarks in proof of the innocent effects of abundant aqueous vapour, of short duration, in the atmosphere, it is not unusual to see the most delicate people of all ages living in very damp situations, without any apparent injury to their health; nor does this state of the air seem to have any influence in counteracting the common effects of different medicines, as we have found them to succeed in the cure of rickets, syphilis, psora, &c.; and fractures mend in such situations equally well as when the atmosphere is in its driest state.

The vapour arising from newly-washed apartments of dwelling-houses and the wards of hospitals, has been supposed to give occasion to an innumerable train of ills. We are accustomed to hear this daily remarked, without having ever experienced any bad effects from it, or having seen others having an illness that could be fairly imputed to this cause. In warm countries, during the hottest season of the year, it is a general custom to dash quantities of water over the floors of the apartments, on purpose to give a freshness to the air; and many ingenious methods are had recourse to, on purpose to increase evaporation,—a practice from which the inhabitants never experience any bad effects: on the contrary, by abating the violent temperature of the air, it is in that way found to confer the most essential consequences in regard to their health and comforts. With respect to the utility of water in hospital-wards, it can require noparticular demonstration or authority to show the impossibility of keeping them in a proper state of cleanliness, without having them frequently washed out. Dirt will accumulate in spite of every other means: it may be glossed over by means of the scrubbing-brush, or varnished upon the boards with wax; but, without frequent ablutions of water, it will never be got properly rid of. Bad effects have been perceived to arise from an opposite custom; but we never could discover any ill consequences follow this practice, either to the sick or their attendants. This observation has been confirmed by physicians long engaged in the most extensive hospital practice; and, by comparing a statement of the mortality that takes place in the infirmary at Edinburgh, where the wards are daily washed out, with that of any hospital in Europe, we shall obtain a convincing proof, that no bad consequences follow from being exposed to the vapour arising from water employed in this way: and it may also be inferred, even in favour of the utility of this practice, that there arises a greater impediment to the cures of the patients in this institution, by the daily visits of at least one hundred and fifty students attending the University, than in any other similar charity.

The decks of ships are regularly washed with water at least once a-day; and even the apartments allotted as berths for the sick are cleaned in the same way: and we have obtained the most satisfactory information, that so far from this practice being considered as detrimental to the sick in impeding their cures, that it is generally looked upon as being productive of much benefit. But although, in general, the vapour of water does not seem to give rise to any ill consequences, it will not be denied, that an unusually moist state of the atmosphere, especially when co-operating with other causes, or succeeding their effects, may not engender diseases of the most serious nature; though it does not appear, that great humidity of the atmosphere is immediately inimical to a sound state of health; yet, as such a condition of the air does not readily assist in clearing the pulmonary and cuticular surfaces of their excretions, in this way, it may be considered as less healthful than when it is impregnated with a moderate proportion of vapour. The diseases that occur from a long exposure to an unusually moist state of the atmosphere, are generally those of debility. We have already remarked, that rheumatism occasionally occurs from this cause, in consequence of the cold produced by evaporation, and consequent obstructed perspiration. Dropsy, catarrhus, and phthisis, are also imputed to its effects; though its influence appears in these rather as an additional exciting cause, by occasioning changes of its temperature, than as giving immediate rise to them.

M. Fagon, and many others suppose, that a long continued exposure to humidity, and certain dews, occasion blight, and other disorders in vegetables. Sir Joseph Banks has lately applied himself to the investigation of this subject, and with Spallanzani, Lambert, and others, he imputes the cause of blight to the growth of a small fungus, which insinuates its roots in the rugæ of corn-stalks, and by its growth abstracts a part of the nourishment necessary for the health of the grain. His observations are of the highest utility in a practical point of view, and forcibly claim the attention of agriculturists, to the improvements he suggests. It would appear from some experiments related in the Memoirs of the Royal Medical Society of Paris, for 1776, that blight, as well as other diseases in grain, may be always produced by sowing late in the season.

Duhamel and Tillet have bestowed great attention on the pathology of vegetables; but in this investigation, the opinions of any two authors are rarely concordant respecting the nature of the morbid cause.

The use of diseased grain in diet, is reported by Geoffroy, in his Materia Medica, to occasion a singular affection of the extremities called dry gangrene, where the fingers and toes drop off. This disease resembles a disorder with which the negro slaves in the West Indies are frequently affected, and probably originates from the operation of similar causes, not merely the use of food affording an imperfect nourishment, but as otherwise possessing some pernicious quality. For a farther account of the diseases occasioned by variations of the weather, we refer to the ingenious papers of Malouin, in the Mémoires de l'Academie des Sciences, from 1746 occasionally till 1754.

There are certain cases of disease in the human race, where it has been supposed that a quantity of water is imbibed from the atmosphere by the absorbents on the surface of the body. In some instances of dropsy, De Haen estimates the quantity thus acquired at about 100 pounds. While Fontana was under the operation of a brisk purgative, he found, that his weight was even increased several ounces, during a walk in the evening for an hour or two, when the atmosphere was moist; but it does not readily appear, how the weight gained in this case could be owing to any absorption by the surface, as his clothes must in a great measure have prevented all communication between the atmosphere and his skin, and they must have also freed the air of its moisture in a considerable degree.

Dr Watson relates a case still more striking in this respect. A boy who had been sweated and starved down to a certain weight, in order to fit him as a rider in a horse-race, acquired an additional weight of thirty ounces in the course of an hour, though he had only drank half a glass of wine in the interval. This must have been owing to the same cause, and assimilated by the same functions, as in the former histories. Dr Chalmers, in his Book on Fevers, gives the case of a negro who was gibbeted at Charleston, and who voided a quantity of urine every morning till he died, though he was not supplied with any liquid. There are many cases where the quantity of urine voided by diabetic patients, is not lessened even when their skins have been covered with greasy applications; and in such instances the excretion in this way has been often found to exceed the whole ingesta: in these cases, the absorption of water could only take place through the lungs. The following fact, gives likewise an additional confirmation of this opinion. Several people who were under the necessity of passing their time in a very damp situation, perceived that they had regular calls during night to void urine; which took place repeatedly, even when their skins were covered with perspiration, and after a dinner of animal food, with a few glasses of wine, and when no supper, or any liquid had been taken for many hours before going to bed. This circumstance continued to be observed for several weeks, till the increasing temperature of the atmosphere rendered the situation somewhat drier. Dr Currie has endeavoured to show, by repeated experiments, that the absorption of moisture does not take place by the skin; and from the foregoing observations, we are rather inclined to embrace his opinion in a certain degree; as it would appear, that the great increase of weight in the instances mentioned, is more especially owing to the absorption of vapour by the lungs. By what particular inlet it gets admission into the blood, remains yet to be ascertained; but it seems evidently situated in the pulmonary system; and it is not improbable, that the same rout which gives access to the oxygen absorbed from the air in respiration, will likewise afford a passage to the aqueous vapour,—a circumstance which seems confirmed by analogy, from what occurs in the cure of syphilis by mercurial vapours, as by fumigation; for in that case it is evident, when it affects the system, that its influence can only be communicated through the lungs.

SECT. IV.

OF THE INFLUENCE OF DIFFERENT ELECTRICAL STATES OF THE ATMOSPHERE ON ANIMALS AND PLANTS.

THAT electricity has a considerable power in promoting vegetation, is decidedly evinced by many accurate experiments, particularly those conducted by Nollet, Beccaria, Jalabert, and the Abbé Bertholon. The latter not only supposes the electric fluid is of the highest utility in directly forwarding the growth of plants, but that it likewise assists vegetation, by banishing such insects as prey upon, and destroy the young shoots. However, there are other respectable names who have not experienced those beneficial effects from the influence of electricity; and several philosophers have even supposed it was attended with noxious consequences when applied to growing plants. Both of these opinions may be correct in certain circumstances: its beneficial or noxious influence will most probably depend on the nature of the vegetable itself; as it is evident that all plants do not combine with one definite proportion of the electric fluid; and a variation in this respect will likewise suffer greater irregularity from the nature of the soil, the temperature, and the proportion of humidity in the atmosphere, and situation in regard to other plants.

Electricity acts on living bodies as a most powerful stimulus; it may therefore be employed in such excess, as to induce the debilitating effects of over-excitement; or, in other instances, it may be so sparingly applied, as to shew no manifest power: nevertheless, there cannot exist a doubt, that a fluid so universally prevalent, and which shews so great an attraction in a free state for vegetable matters in general, must perform some highly essential purpose in the process of vegetation. In the 35th volume of the Journal de Physique, there are some decisive experiments, showing the utility of electricity on plants in every stage of vegetation. Moulard, d'Ormay, and Carmoy have shown, that it is of equal advantage in the germination of seeds, as it is in the after-growth of the plant. It has been formerly remarked, that light is unfavourable to the germination of seeds; Bertholon opposes this opinion, by stating, that this only appeared in consequence of the increased evaporation from the admission of electricity, along with the rays of the sun. This ingenious philosopher gives the description of a machine, which being stuck into a field, attracts the electric fluid from the atmosphere, and then disperses it over the crop. He finds this "heavenly manure" to be of the greatest service in this way; and he uniformly experienced, that those plants grow most vigorously, which were in the immediate vicinity of this conductor. On the other side, M. Hassenfratz opposes his experiments to these conclusions; and Ingenhousz expressly says, that, on repeating the experiments of Bertholon, he found none of them succeed, though, he seems to admit, that the plants which he used as standards in his experiments, and which were placed near an electrical machine, appeared to vegetate quicker than those to which the electricity was directly communicated. Probably the following remark by Fourcroy, may, in a certain degree, account, for these different results. In a paper in La Medicine Eclairée, it appears, that electricity, when conjoined with the influence of water, is an useful auxiliary in promoting vegetation, but otherwise it is hurtful; its power on a hatch of eggs did not appear to give any particular result: but there are many proofs of thunder having a very bad effect upon grain even after being gathered, and in some cases it probably destroys its reproductive quality.—See Mémoires de Meteorologie by Pere Cotte, vol. i. p. 94.

There are many instances to show that electricity serves some essential purpose in the animal economy; its immediate influence on it is probably not dissimilar to what it occasions in plants; and it may be reasonably expected, that the ardour with which the study of galvanism is prosecuted at the present time, will speedily tend to give an elucidation of this interesting subject. It has been remarked by those who have travelled in Siberia, where the aërial electricity seems to abound, that it increases the irritability of the natives, particularly of the women. It has been already observed, that the electric condition of the atmosphere is altered by respiration; it seems therefore not improbable, that in the performance of this function, a quantity of that fluid is communicated to the system. Every animal appears to possess a portion of electric fluid: this is demonstrated by what takes place in galvanic experiments on the living body; the same thing is demonstrated by repeated friction along the furs of some animals: and it is manifested in man, when stripping himself of garments made of stuffs which are bad conductors of that fluid; as in throwing off a silk stocking, or a flannel shirt, a crackling noise is commonly heard, and when performed in the dark, is accompanied with sparks of fire. It seems likewise very probable, that the same fluid occasions that appearance of light which is observed to dart from the flowers of certain plants, as the marygold, orange-lily, &c. after sun-set in hot summer weather. All animals do not probably contain an equal portion of electricity, nor does each individual of the same kind; its general effects being that of a stimulant, when applied in a high degree, it kills by destroying all nervous sensibility. Animals killed by lightning, resemble in many circumstances those that have been destroyed by breathing certain poisonous winds. Chardin relates, that people killed by the samiel, seem as if they were asleep, and that their limbs are easily separated from their bodies even by handling them. It is also remarked by Volney, that a person killed by the kamsin wind, remains long warm, swells, becomes blue, and is easily torn,—appearances agreeing to those discovered in people killed by thunder. Richard observed, that the electricity of the atmosphere is most frequently evinced in places over which there is a particular stratum of air, as in farm-yards, stables, and such places: this is most likely occasioned by the changes the air undergoes in those situations; the electricity being diminished during the alteration of its other chemical principles, and possibly it may be in consequence of similar causes that particular districts are observed in every country where electric meteors prevail most frequently. Lightning, with, or without thunder, is known to have a very pernicious effect on several matters; it stops the regular fermentation of liquors, turning them sour; it produces the same effect on the contents of the dairy; meat becomes sooner tainted; and sores lose their disposition to heal, &c. Richard supposes, that these changes are occasioned by a quantity of sulphureous acid abounding in the air in such circumstances; but if the effects we have mentioned be owing to the prevalence of a matter in the atmosphere possessed of the properties of an acid, it seems more probable that this should be the nitric acid. Mr Hayes has a paper in the 4th vol. Bath Society Papers, wherein he shows, that an acid is at all times prevalent in the atmosphere of dairies; this is demonstrated by exposing in them a quantity of the syrup of violets, which is thereby turned red. Cream absorbs oxygen gas from the atmosphere, and possibly carbonic acid is emitted in consequence: should this observation of Mr Hayes be actually found to be the case in every situation, a quantity of fresh burnt lime kept in milk houses, might serve a useful purpose in preventing the souring of milk from this cause. It likewise appears from the experiments of M. Achard, that electricity accelerates corruption; and it is owing to its accumulation, that the putrefaction of flesh takes place so rapidly after a thunder-storm. M. Hemmer likewise, in a paper in the sixth volume of the Manheim Transactions, says, that cold changes positive or natural animal electricity into the opposite kind, or at least lessens it.

But that nitric acid is also occasionally produced in the atmosphere, during the prevalence of thunder and other electric meteors, seems probable from what is known of the effects of that fluid, when passed through a quantity of its constituent gases, nitric acid being then produced; and during the tendency of electricity to acquire a state of equilibrium in the air, a small portion of the same fluid may be generated; the farther probability of this opinion is evinced by the peculiar smell that always succeeds the appearance of thunder.

Electricity is strongly attracted by all living animals: still there seems to be a peculiarity in certain constitutions, that enables some people to resist the impulse of lightning better than others: the same thing is also observed to take place amongst the vegetable tribes; trees containing a resinous juice are seldom or never struck by lightning, as the laurel, olive, the pine, &c.; while such as contain a watery sap, seem rather to attract it.

Some people feel very unwell and uneasy before it thunders, and even preceding every change of weather, where an alteration in the electrical condition of the atmosphere is supposed to take place. Again, there are innumerable instances, where the money has been melted in the pockets, by the effects of aërial electricity, without the person receiving any other injury. Richard gives the case of a lady, whose house stood on an elevated situation in the province of Burgundy; where the lightning broke repeatedly into her bed-room, leaving marks on her person as if caused by the stripes of a horsewhip. The lightning broke into the apartment of the Abbess de Royale Lieu in Compiegne, on the 10th August 1769, and burnt the slippers from off her feet, without inflicting any personal injury. Indeed, there are many instances given by authors, which seem to show, that the electric fluid has even a predilection for particular spots of the body; from which circumstance, many whimsical occurrences are said to have happened. There is a very singular deviation in the effects of thunder, that deserves to be mentioned here, and which is perhaps first noticed by Pliny. A Roman lady, named Martia, was struck with lightning while pregnant, and was immediately thereafter delivered of a dead child, without suffering any unusual inconvenience. The accuracy of the opinion respecting the supposed cause of the child's death, is farther corroborated by the occurrence of a similar accident, as related in the Acta Erudit. Lipsien for 1713. A pregnant woman of Altenberg, a city in Higher Saxony, was struck with lightning, from which she experienced no immediate injury; but some hours after, she fell into labour, and was delivered of a dead child, seemingly half burnt, whose body was quite black.

Aristotle remarks likewise, "si incubante galina tonet, ova pereunt;" and an effect of thunder similar to the above is said by Pliny not to be unusual when it strikes upon pregnant cattle, an observation which is corroborated by common experience. The procurator of the seminary of Troyes was killed by lightning, and his bones were all found broken, without an appearance of external injury. Muschenbroeck relates a similar instance, which came within his own knowledge; during a thunder-storm, the lightning struck a flock of sheep, which were all instantly killed, and their bones broken into minute pieces, and dispersed through the flesh without any external lesion.

The ancients remarked, that not only some plants, but certain animals, were also exempt from the influence of electricity. Of the latter, Pliny specifies the vitulus marinus, or sea-calf, and the eagle; and he observes, that it was probably owing to this property in the laurel, that occasioned it being first employed as a garland for crowning victors.

The methods that are most generally employed for the purpose of averting thunder-storms, are the ringing of church bells, and the firing of large pieces of ordnance. Regarding the first, it must be observed, that by general experience it has been found to be both ineffectual and dangerous. On ringing of bells during a thunder-storm, sparks have been seen to issue from the bell at every stroke of the hammer; and there are many instances on record, of people having been actually killed while performing this task. Richard particularly mentions the death of two young men in this way, which happened on the 31st March 1768, at Chaubreuil in Dauphiné. But were this method effectual, or in other respects advisable for the dispersion of thunder, it is obvious that the bell-rope must be formed of some non-conducting substance; and even then, it would be still a very incautious practice.

It is mentioned by Forbin, that the Count d'Estrées, while governor of Carthagena, successfully practised the firing of cannon to dissipate or keep off thunder-storms; but the repeated experience of an opposite effect being produced in this way, has rendered its efficacy very doubtful. Nevertheless, it has been recently revived in some parts of France, and is said to have been attended with success. The firing of cannon on the 10th May 1794, in an affair between the British and French troops in the neighbourhood of Tournay, was, apparently with good reason, imputed as the cause of a very severe thunder-storm, which commenced a short time after the engagement had begun, and continued an hour or two after the firing had ceased. Many similar instances might be referred to, which evidently show, that the general concussion of the air occasioned by artillery, tends rather to bring on thunder; therefore Richard very properly cautions every person against walking in opposition to a thunder cloud, as the regular current of the atmosphere may be thereby broken, and fatal consequences have in this way frequently occurred. The ancients had observed, that the lightning of thunder never penetrates deeper than five feet into the earth: on this account, the Romans were accustomed to conceal themselves in caverns during such conditions of the weather. When it thunders, the emperors of Japan hide themselves in a vault, covered with water, and built as a cistern. Suetonius mentions, that Augustus was terrified in a very uncommon manner when it thundered; on these occasions he commonly put on a cloak, formed of the skin of a sea-calf, and in this dress confined himself in a vault. The most certain way of preventing the effects of lightning, is to follow the example of the Japanese princes, when such an opportunity offers; otherwise, it is proper to keep at a distance from all bodies by which electricity is conducted, and to get into a situation completely isolated by non-conducting matters. In this state of the weather, garments of silk are much safer to be worn than perhaps any other material of which dress is made. When within doors, during thunder, people ought to keep at a considerable distance from the walls, fire-place, or windows; and this precaution is still more necessary when the room is ornamented with mirrors and pictures. If taken with a thunder-storm when abroad in the fields, it is proper to keep at a distance from trees, out-houses, fields of growing corn, &c. and even from other animals. No precaution ought to be taken in guarding against being wet with rain, as the more completely a person is drenched, so in proportion is his danger diminished. Perhaps the best posture a person can assume in such circumstances, is to lie down flat on the ground; he will not in that case oppose an attracting point to the electric clouds, as he is very apt to do when walking or riding. Richard records the case of a gentleman of his acquaintance, who was struck by lightning at an early period of life, while sitting by a lady, He immediately fell down seemingly dead, and was in that state conveyed into a warm bed, where, by the power of cordials and rubefacients, after two hours exertion, he was entirely recovered, and in the course of a short time regained his former health.

Having in this manner gone over the leading circumstances of the various states of the atmosphere, which, as constituting the difference of climate, seemed more particularly to require our attention; we have now to proceed to point out the general properties of such extraneous matters as are most commonly found in that medium, and which, in accumulated proportions, tend to the same effect.

CHAP. III.

OF THE NATURE AND INFLUENCE OF EXTRANEOUS MATTERS IN THE ATMOSPHERE, ON ANIMALS AND PLANTS.

SECT. I.

The properties of oxygen, azotic, and carbonic acid gases, have been already pointed out, when treating of the permanent principles of the atmosphere; and it would involve the history of an immense variety of natural bodies, which otherwise do not fall to be mentioned in a treatise of this nature, were we to proceed to investigate the properties of every substance that may be occasionally discovered in that fluid. The following observations must be therefore limited to a few remarks on hydrogen and its compound gases; these being the extraneous bodies most usually found in the atmosphere.

Hydrogen gas very rarely exists in the atmosphere in such proportion as to produce any general change in it, that could be manifested by its effects on living bodies: it has been observed sometimes abounding in the vicinity of volcanoes, in a state nearly pure; and the dreadful consequences occasionally produced by its extrication at the bottom of mines, are innumerable, and occur frequently. But except in this last situation, hydrogen gas does not remain in the stratum of air near the earth's surface; being of much less specific gravity than that medium, it naturally tends upwards, and is speedily diffused through it; however, when it is met with in considerable quantity, on being respired, it is very unfriendly to animal life, yet vegetables live for some time in it, and it enters copiously into their composition. Hydrogen gas possesses transparency, and the elastic properties of aërial fluids, and emits a peculiar faint odour when breathed; its specific gravity is less, and its specific heat greater, than any other gaseous body: it forms compounds with many of the simple substances. When combined with oxygen gas, by means of electricity or combustion, in the usual way, it forms water and muriatic acid; with azote it forms ammonia; it is likewise capable of dissolving phosphorus, sulphur, and carbon. When it unites with carbon, there is formed a compound gas of the most deleterious properties to animal life, occasioning instant death by respiring it. This gas is frequently evolved in processes going on at the earth's surface. It is commonly found abounding in marshy places, from which it may be seen to rise in hot weather, or at any season when the mud at the bottom is agitated or stirred up. This compound air is highly useful in vegetation, and it has been supposed by Dr Beddoes, to be the most necessary food of plants, from which they chiefly acquire the carbon in their composition; and it is probably as much to be imputed to the presence of this gas, as to the humidity in marshy grounds, that vegetation is more luxuriant in the vicinity of such places.

These airs are not, in any circumstances, essential in the composition of the atmosphere; and like every other heterogeneous fluid, they will impart to it properties resembling their own, corresponding to the quantities in which they exist in it. Even the gases composing atmospherical air will have this effect when they exceed their natural proportions, as in these circumstances they stand in the same relation to it as any other foreign matter.

SECT. II.

OF EPIDEMICAL CONTAGION, AND OF MARSH EFFLUVIA, THEIR CAUSES, MODES OF ACTION, AND OF THE METHODS FOR PREVENTING THEIR EFFECTS.

Besides those diseases which we have mentioned, as depending in a great degree on the influence of climate, disorders generally prevalent at the same time in every country, and similar in the description of their symptoms, have frequently appeared in every æra of mankind: those are what are denominated contagious and epidemical diseases, whose causes have been supposed to arise from some temporary peculiarity in the constitution of the atmosphere itself, or to be generated by its adventitious mixture with some deleterious matters. There have been some physicians of the highest respectability, who have ascribed febrile contagion to a divine origin; but in latter times, the followers of the former opinions have been most numerous, though in frequent instances they have failed in maintaining consistently their particular theories; and it is therefore not unusual to find in their writings, both of these causes confounded in explaining the same common malady.

From the earliest period that medicine has been cultivated, and its study included amongst the liberal sciences, the cause of general disorders has been assiduously sought after, the dearest interests of society being connected with the research: we therefore find physicians of the greatest eminence for their ingenuity and talents, employed in the investigation.

The subject is of extreme difficulty, not only from the variety and impalpable nature of the causes themselves, but also from the peculiar functions and various idiosyncrasies of the living system on which they act. It is much to be regretted, that want of uniformity of opinion, is so conspicuous in works on this subject; while one sect has most obstinately denied the power of adventitious matters existing in the atmosphere, as being productive of epidemical disorders, others have assumed the appearance of those foreign matters or contagion, as the causes by which they are solely excited. At no period has the dispute been agitated with greater keenness than at the present day; and perhaps at no æra in the history of the world, has this subject claimed, in a higher degree, the attention of mankind, from the frequency of the appearance and the malignancy of such disorders.

In the following discussion, it shall be our endeavour to investigate the supposed influence of the atmosphere in occasionally engendering epidemical diseases; in the second place, we shall attend to the nature of those matters, which are imagined to have the same power; and, thirdly, we shall consider the influence of the atmosphere in propagating their effects.

It is rather singular, that few of those authors who have maintained that epidemical diseases are propagated by a peculiarity in the nature of the atmosphere itself, have communicated any idea of what this supposed alteration of its qualities consists, during the prevalence of such complaints. Paræus imputes the occurrence of plague to an alteration in the natural properties of the air, without giving a precise definition of them; but as he also talks of its putrefaction as arising from the exhalations of other matters, his opinion cannot be therefore regarded on this subject as decided. But that a change of the properties of the air, independent of the mixture of any accidental impurities, was generally esteemed as giving origin to epidemical disorders, and continues down to the present time, may be collected from many authors who have written on this subject. The following quotation from Mindererus is therefore selected, as affording the most distinct view of this opinion: he says, when treating of the plague, "Longe porro communior pestis causa esse solet aër; non is veneno quidem aut putredine vitiatus, sed inordinata primarum qualitatum subsecutione, noxius, utpote cum is modo in calidum, modo in frigidum, aut siccum declinans, fortuito quasi eventu, multoque temporis habito respectu ac ratione, præpostero plane ordine, nunc in hieme calet, nunc friget in æstate." Dr Maclean, in the appendix to his View of the Science of Life, p. 20. in treating of this question, observes, "Certain states or vicissitudes of the atmosphere, together with the application of other powers, producing indirect debility, are the cause of all epidemic and pestilential diseases which affect the same person more than once during life, and have hitherto been reputed contagious. In page 180. of Dr Arbuthnot's Essay on the Effects of Air, this learned physician advances the following opinion respecting this question: "Whether the air is capable of producing the plague without infection, in a place where it is not an endemial disease? I think the affirmative is very probable; for, 1st, In a country where it is both an indigenous and endemial disease, it must be probably owing to some particular quality of the air; 2dly, It has been proved, that there is hardly any alteration, even to the utmost degree of putrefaction, but may be produced by the enormities, combinations, and alterations of the common qualities of the air; and that still more extraordinary effects may be produced from some contagion from the air, by uncommon effluvia from bodies near the surface of the earth." The greater part of the chapter contains arguments in support of this doctrine; but, like almost every author who has assumed this side of the question, the Doctor is by no means sufficiently accurate in making a distinction between the natural effects of the changes of the physical properties of the atmosphere, and of the effects of such matters as may be occasionally mixed with it. In Dr Adam's elaborate work on Animal Poisons, the same obscurity pervades the investigation of this subject: in page 320, he mentions, as a cause of fever, "a state of the air in its cause, unconnected with living animals, but equally affecting all who come within its influence, as intermittents from marsh miasma, influenza, or any other endemic or epidemic disease." In page 354. of the same work, he continues, " If what we have said be admitted, it will follow, that fever from infectious atmosphere is to be ascribed to the confined effluvia from living bodies,—the yellow fever from the effluvia of putrid animal or vegetable matter exposed to a hot sun,—and the plague to the latter, joined to an epidemic constitution of the air; that in all, a *fomes* may excite the disease; yet we are not certain, whether a diseased subject is contagious, unless in a certain atmosphere." In such terms, he admits the existence of contagion, and seemingly attributes a power of equal influence to the atmosphere also.

But the effect that may be supposed to be produced by any alteration of the atmosphere in the manner thus pointed out, would certainly rather tend to excite such diseases as generally arise from variations of the climate. It is impossible to comprehend, how a change in the physical properties of the atmosphere, capable of engendering any general disease, should take place, without other circumstances connected with that change upon other bodies becoming manifest. Were the above opinion correct, this must have been always the case, considering the variety of such diseases. Neither is it easy to conceive, how an alteration in the constitution of the air, rendering it so virulent as to occasion any pestilential disorder, should not affect every one at nearly the same time; as, in every condition of the atmosphere, it must act upon man, and all respiring animals, in nearly a similar manner: therefore, did any epidemical malady really originate from this cause, few or none could escape its malignity; and the brute creation must have been in that case equally afflicted by it as mankind. But Plenciz assures us, from the result of long experience, that the epidemical diseases of cattle are rarely or never communicated to their herds, or even to their dogs: in this general observation, hydrophobia is to be excepted. On the other hand, it requires no authority to demonstrate, that the diseases of man are never transferred even to domestic animals. A full investigation, in proof of these remarks, is to be found in the preface to Muratori's work on the Management of the Plague.

It must likewise be observed, in opposition to the opinion of a change of the physical properties of the air being the cause of epidemics, that there are countries where formerly the plague seems to have rarely or never appeared, and where it is now a very frequent visitant. Pestilential disorders were also more frequent in Europe in former times: there has none appeared in the British Isles for these last 150 years; whereas formerly they were very frequent. Considering these circumstances, it can scarcely be supposed, without a considerable latitude of imagination, that the atmosphere over any of those places has undergone an alteration in its physical qualities, or in the chemical combination of its principles, so as to render it capable of being the cause of pestilence of any kind, or of preventing it; for we have seen, by the experiments of Berthollet on the analysis of the atmosphere, that the air of Egypt does not differ in its physical or chemical properties from that of the most salubrious climate of Europe; and this was demonstrated even when the plague prevailed in that country.

The dreadful epidemic which desolated Malaga, Gibraltar, and other places of Spain, in the summer and autumn 1804, has been affirmed by many who were eye-witnesses of the ravages made by this malignant distemper, to have been generated by some peculiarity in the constitution of the air itself; the disease having broken out at the same time in different places; and where no other cause for its origin could be traced. The limits of this essay only permit us to give a concise outline of the progress of that plague, so far only, that the correctness of this cause to which it has been ascribed may be more completely ascertained, or its fallacy refuted. Malaga was the city where it originally appeared; and it continued to be confined for a considerable time to its boundaries, in consequence of the measures of precaution that were used in preventing all communication between the inhabitants of the infected city and those living in the surrounding country; and even when the disorder appeared in other places, in consequence of the escape of many of the inhabitants of Malaga through the cordon, they having penetrated into the interior of the kingdom, still many towns remained free of the disease; and even places lying in a line with, and at no great distance from others where it raged, were found to escape its effects. All these circumstances considered, it is impossible to understand how that pestilence could be occasioned by any particular condition in the natural properties of the atmosphere; and that men of nearly the same habits, using the same sort of diet, breathing the same common atmosphere, and of course strongly resembling each other in constitutional idiosyncrasies, should not be susceptible of the power of the same general causes, nearly in an equal degree. It therefore becomes evident, that had the cause of this common disorder depended on the supposed general malignant qualities of the atmosphere, it must have been still more prevalent and more fatal than it has even appeared.

Similar exceptions to those just mentioned have been remarked by many authors who have written on pestilential disorders. Towns placed in a direct line with, and in the vicinity of others where the disease has prevailed, have been observed to escape it altogether, and in situations too, where, by contiguity and other local circumstances, the state of the atmosphere must have been alike in all of them. Muratori gives the following amongst other instances of this kind that fell within his own knowledge: "Nel ducato di Modena, le terre di vignuola, Guiglia, et tante altre castille della collina, et della montagna quantunque confinante ad altre infette della pestilenza, o circondata di essa, pure col mezzo delle guardie et delegenze usitata schivarano cosi terribil disaventura." Mead says, that when the plague was last in England, while it raged in the town of Cambridge, the colleges remained free from it, by keeping apart from the town's people; and he quotes Gastaldi, who observed, that in a plague at Rome, in 1656-7, the monasteries and nunneries for the most part defended themselves, by using the same precaution.

In this manner, it appears evident, that neither the physical nor chemical properties of the atmosphere are altered in countries during the prevalence of plague; nor is it probable, that in the rise of any epidemical distemper this ever appears as an immediate exciting cause.

We have next to consider the importance of some facts, which, by showing the influence of seasons in producing or propagating epidemical diseases, enable us to decide respecting the supposed influence of the atmosphere as a cause of such complaints. The second time the plague is recorded to have broken out in Athens, it was in the beginning of winter; and Thucydides observes, that it proved so fatal, that in a very short time 4040 foot soldiers and 300 cavalry were cut off by it, with a proportionate number of the inhabitants. Galen also mentions an instance of a plague having invaded Aquileia in the middle of winter. Guido de Chauliaco gives the history of a memorable plague that pervaded the whole globe in 1348, and destroyed three parts of its inhabitants; neither was it stopped by the different seasons or changes of the weather. Sydenham, Dover, Mead, and Brookes, give many similar instances of pestilential diseases appearing during winter, and remaining through that and the succeeding seasons. Muratori relates, that "la peste dell 1630 fu al sommo a Padova ne mesi di Guigno et Luglio, ma in Venezia, la stessa fece strage maggiore nell Ottobre, Novembre, et Decembre, continuanda poi tutte l'anno sequente 1631 sempre diminuenda." The epidemic known by the name of influenza has been observed to break out in Europe at every period of the year: it prevailed all over the continent in January 1803, and proved then most fatal, and during the months of February and March immediately succeeding. In 1782, the same species of disease made its appearance in Britain, during the heat of summer, and raged most violently when the temperature of the air was greatest. It hardly requires to be suggested, in addition to the above, that small-pox, measles, and scarlet fever, have been epidemical at all seasons of the year.

From these facts, any farther observations tending to elucidate this point appear unnecessary; and it can hardly be supposed, that the changes which the atmosphere undergoes in the vicissitudes of season should be capable of producing one common and defined malady, affecting mankind generally, the natives of every region, whose constitutions and habits are so greatly diversified.

Having now gone over, in a general way, such facts as stand in opposition to the opinion that epidemical disorders are generated by an alteration in the physical properties of the atmosphere, we have next to make a few observations on the writings of some of those physicians who have most strenuously denied the existence of a peculiar matter in causing epidemical distempers. We are prompted to proceed in this inquiry, as, by examining their opinions, the conclusions drawn from the foregoing observations will be placed in a stronger point of view.

In every medical dissertation, it is usual to quote the opinion of Hippocrates on the subject; but, in the instance of contagion, his writings afford us little or no information. In some places of his works, he seems to have ascribed the cause of plague to the influence of the air; but he regards it in every instance as occurring in consequence of the immediate will of the Almighty ; on that idea, he denominates its peculiar causes *divine*. This opinion he very probably borrowed from some of the Asiatic tribes, amongst whom, we know, this peculiar tenet prevailed, "Quæ afflictio, quæ lues civitatem corripiet, quam non magna Dei manus intulerit?" This opinion continued to be implicitly followed, even down to the time of Diemerbroeck. But Gregory Nissenus is perhaps the first who expressly denies the existence of contagion as a cause of disease, though he does not seem to have substituted any other more probable reason for the appearance of epidemics. We quote his theory from the writings of Mindererus; and never was there an opinion supported by more whimsical reasoning: his words are, "Gregorius Nissenus, summus alioquin philosophus, nec medicinæ ignarus, in expositione dicti illius, a Domino Salvatore nostro prolati, 'Quod uni ex minimis,' &c. in medium adducit, nullum morbum contagiosum esse asserens, ideo quod sanitas quæ morbo opponitur non sit contagiosa, eam contrariorum eadem et par ratio esse solet;" the reasoning is so absurd, that it hardly deserves to be repeated, and is only quoted here as being used by one of the earliest writers, who support the non-existence of contagion. Mr Noah Webster of America is one of the most zealous of the moderns, who endeavour to refute the existence of contagion, by referring the appearance of epidemics to the influence of variations of the atmosphere; he goes very fully into the subject, and his work affords a tolerably good view of the history of pestilential disorders: however, at the close of a very tedious discussion, he concludes in terms not dissimilar to those which would have been used by any person entertaining a different opinion; and he therefore most completely fails in establishing the favourite hypothesis with which he sets out. Assalini, one of the physicians to the French army in Egypt, has published a treatise on the diseases peculiar to the army in that country; wherein he expressly denies, that plague is propagated by a matter *sui generis;* that in fact it is not contagious: nevertheless, he does not appear to have succeeded in establishing any other directly exciting cause for it; nay, the very arguments he uses in support of his opinion, may be advantageously turned against himself. In several places of his book, he shows that his mind was by no means divested of the preconceived prejudice regarding the existence of contagion; he takes great pains to detail the methods he followed to preserve himself from becoming affected with this complaint, and the means he employed are certainly very judicious.

But if contagion has merely an ideal existence, which seems to be his decided opinion, it must appear as the greatest degree of mental weakness to take any trouble in guarding against its effects; as, according to this theory, the atmosphere surrounding a patient ill of the plague, or typhus, should not be more noxious than the vapour arising from a person confined with rheumatism or a sprained ancle. This is expressly asserted to be the case by Deidier, who affirms, that the atmosphere of a person labouring under plague, is no more to be dreaded than that of a person sick of the venereal disease: and accordingly he asserts, that the dressing of pestilential buboes, and the performance of the common offices to those sick of the plague, is not attended with any danger. Stoll likewise delivers an elaborate discourse against the existence of contagion. For a further relation of such opinions respecting the manner how the plague is propagated, we refer to the Traité sur la Peste, containing the works of Chiconeau and others, who have written of that disease, as it appeared in Marseilles beginning of last century.

The contagious nature of plague and febrile diseases in general, has been combated with many ingenious arguments by the learned Dr Moseley, whose knowledge of science, and extensive professional experience, entitle his opinions to be received with the greatest respect. In one place of his Treatise on the Diseases of Tropical Climates, he observes, that "epidemical diseases can have but one general and immediate cause; for what cause predisposing can exist, where every diversity of habit of body, and age, is subject to the same symptoms, and cured by the same remedies?" This sentence appears very singular for one who denies the power or even the existence of contagion, as it may be turned with equal facility to the defence of the doctrine which it is meant to refute. Every one is aware, that there are diseases resembling in type the worst species of epidemics, which are uniformly confined to the space where the causes exciting them continue active, and, except in cases of the worst management or neglect, are never propagated beyond their original source, and which therefore can never be considered as epidemic. On the contrary, whatever may be its exciting cause, or wherever it may take its origin, an epidemic once formed has the property of generating a matter in its progress, capable of propagating a certain defined malady at any distance from its primary exciting cause, and under every circumstance and variety of climate. The former class of diseases is uniformly propagated every where by the influence of exhalations or miasma of marshes, and they never exist but in the vicinity of such places: accordingly, different districts are found to be more liable to produce such complaints than others: from this cause, the intermittents common in the fenny counties of England, and the intermittents and remittents of warm climates, have their origin; therefore these disorders are never communicated to others, unless by being exposed to the influence of the same cause; and in no instance are these disorders ever propagated from one person to another. At the same time, it is to be observed, that fevers arise sporadically from the operation of marsh effluvia, and many other causes, even more evanescent in their operation, as irregularity of the passions, cold, fatigue, &c. and where the disease, in the first instance, is not contagious; nevertheless such diseases, in cases of neglect and preposterous management, are found to become more malignant even in the most temperate climates, and to generate a matter in their course capable of producing a particular disease in any circumstances. Indeed, the origin of every contagious fever, unattended with eruptions, with the exception of plague, must have its origin in this way.

Dr Moseley seems to imagine, that he has completely refuted the opinion of the contagious nature of yellow fever of the West Indies, and with exultation puts the proposition, " How a climate should foster a disease, and a contagious one, and the natives of that climate be exempt from it, I cannot comprehend: but the whole story is fabulous; therefore it is unnecessary to reason on it." This fact does certainly afford a subject of curious, though difficult research; but the observation is by no means limited in its application to the endemial and epidemical fevers of a tropical country; and it does not appear necessary to draw the conclusion Dr Moseley seems to infer from it, although we may not be able fully to comprehend the cause of this peculiarity. However, we shall immediately find, that the exemption from contagion is by no means to be considered as a proof that it does not exist.

The Africans transported to the West Indies cannot be regarded as the natives of that climate, with greater propriety than the colonists from Europe. The former are known to be less liable to almost every species of disease than the latter,—a circumstance, combined with others, which has been supposed to afford a strong proof of the original distinct races of mankind. The aborigines of our West India possessions are extinct, or nearly so; the race we must therefore consider as the natives of those colonies, are the mulattoes, and people of colour, descended from the connection between the European and the African; and there certainly does not exist any proof that this class of men are more exempted from the endemial or epidemical diseases of their country, than what takes place amongst the natives of any other climate. Alpinus has distinctly pointed out an illustration of this circumstance, in his Treatise on the Medical Knowledge of the Egyptians, when describing the endemial remittent fever which is so frequent about Alexandria, as well as many other sea-port towns on the Syrian coast, which is in many respects similar to the endemial yellow fever of the West Indies: he says, "Incolæ quam advenæ difficilius corripiuntur, et ab his intereunt." But Dr Hunter, in his Work on Tropical Diseases, records a fact which sets the observation of Dr Moseley in a still more striking point of view, though it does not afford any inference to be drawn from it of the non-existence of contagion; on the contrary, it holds to view an excellent illustration of the power of constitutional habit in overcoming the most baneful effects of climate. It was found, that scarce one out of twenty of the soldiers sent on the St Juan expedition survived it; yet not one of the negroes who accompanied them died on that duty; and there is a circumstance which makes it more to be wondered at, as they were employed in all the hardships and drudgery of the enterprize.

Exemption from the contagion of epidemics is found recorded in the history of every pestilential disorder: this frequently only reaches particular persons; at other times particular orders of men are included. Procopius affirms, that in the dreadful plague at Constantinople in 543, which continued between two and three years, none of the physicians or attendants of the sick were affected by it. Lord Clarendon, likewise, in the History of his Own Times, says, that a plague which raged in Britain in 1665, was chiefly fatal to the lower orders of society, and that few of the better sort died of it. Mercurialis observed, that in a plague which was more violent about Pavia than elsewhere, the indolent, luxurious, debauched, and men-servants, were most liable to be affected. Pliny thought old people were not so apt to catch the contagion of plague, an opinion which has been supported in latter times by Paræus. Dion Halicarnassus records the account of a pestilence that broke out in Rome, by which virgins were only affected, though a former plague, mentioned by the same author, attacked all classes indiscriminately. A disorder, probably not dissimilar to the first, is said to have prevailed at Manchester some time ago, being uniformly attended by a sphacelation of the pudenda in unmarried women. This exemption was most remarkable in that species of plague which appeared in Britain in the 16th century, called the Sweating Sickness: it is asserted, that foreigners living at that time in England were not affected by it, although equally exposed to its causes; that it even seized Englishmen abroad; and did not extend to Scotland.

We quote the following passage from p. 208. of Russel's Treatise on the Plague, as it serves to establish the correctness of the view we have taken of this discussion: he says, "If, of an hundred persons exposed to the infection of the plague, by a near approach to the sick, ninety should fall sick; shall human inability to assign satisfactory reasons for the preservation of the other ten, be converted into a positive argument against the disease having been caught by contagion? If persons retired from all commerce with the infected, and their attendants, breathing the same air with the rest of the inhabitants, and nourished by the same aliment, remain untouched during the rage of the plague, as long as they continue secluded, but upon unguarded communication, are taken ill like others, can any rational doubt arise about the cause of their former security? or if, through stealth or neglect of requisite precaution, substances tainted by the sick should be conveyed into those secluded retreats; and persons living temperately as before, ignorant of what had happened, and consequently in the midst of imaginary security, happened to be seized with the distemper, can it, with any show of reason, be ascribed not to contagion, but to terror, or to colluvies in the stomach and bowels, produced by intemperance and bad aliment?

"The instances here alluded to, are not the creation of fancy, but strictly consonant to repeated experience in Turkey, to say nothing at present of what has been observed at Marseilles, and in various cities of Europe."

But in proof that the exemption of certain individuals from epidemics depends on a peculiarity of constitution or habit, it is known, that many people resist the virulence of scarlet fever, measles, and even small-pox; diseases which have never been said to originate independently of contagion: on these grounds, it is not improbable, that the exemption stated by Dr Moseley arises in consequence of this constitutional peculiarity.

"At forte objiciat quispiam," says Hippocrates, "cur igitur non omnibus animantibus, sed alicui ipsorum generi ejusmodi morbi contingunt? cujus rei causam esse dixerim, quod corpus a corpore, natura a natura, et alimentum ab alimento, differt. Neque enim cujus animantium generi eadem sunt commoda aut incommoda, sed alia aliis conveniunt." The knowledge that has been acquired of the animal economy, and of physical science in general, is by no means equal to the task of explaining, in what the peculiarities of constitution consist: this most probably depends on an endless variety of causes, of which but a slender proportion is presented to observation. However, the instances adduced, afford a corroboration of the conclusion we have already drawn, and do not warrant us to suppose, that epidemics do occur, independent of a definite and specific cause, or that this cause arises from any peculiar state of the atmosphere, in regard to its ordinary physical or chemical qualities. The agency of these properties being necessarily the same every where, any alterations they occasionally suffer must be partial, and their effects will not therefore be observed beyond the sphere of their action. Indeed, it will be afterwards shown, that the atmosphere is the most powerful agent in destroying the virulence of contagion, and in preventing the dissemination of epidemical distempers. This inference is likewise strictly agreeable to the opinions of philosophers of the highest repute for professional talents. Fracastorius, treating of the plague, says, "Rarissime contigit, ut aëris corruptione pestilentia contingat." Alpinus likewise, whose residence in Egypt afforded him most excellent opportunities of ascertaining the influence of the atmosphere in producing this worst species of epidemic, observes, that " plerumque pestilens contagium in Egyptum ex multis locis peste infectis asportari solet; rarissime ab aëris vitio pestis illuc nascitur, et hoc nonnisi ubi Nilus immodice ea loca inundat." And Diemerbroeck also, whose observations are deservedly held in the highest degree of estimation, says, that he could not discover the plague ever to have originated from a change in the qualities of the atmosphere. There is a considerable variety in epidemical disorders,—a circumstance that bears a direct proof, that each order is occasioned by a peculiar specific cause, though it may be difficult, or even impossible, in the present state of medical science, to distinguish this difference, in the rise of every general distemper.

Diemerbroeck, speaking from his own experience, says, that the plague is not caused by famine, nor was it generated by the putrefying remains of 8000 Germans, besides horses, who were left slain on the plain of Juliers, in summer 1642, but a very bad malignant fever took its origin from that cause: and he likewise mentions, that a similar disorder immediately appeared, after several engagements between the Austrians and Swedes, owing to want of attention in burying the dead. But in a warmer climate, the operation of similar causes has been known even to generate diseases, which in their progress give rise to the plague itself: amongst other instances, Paræus relates, that in his days a severe plague, that spread all over Tuscany, was generated by allowing the body of a whale to putrefy, which had been thrown upon the sea-shore. In Pere Cotte's Treatise on Meteorology, he gives the history of the case of a grave-digger at Montmorenci, in 1773, who, by accidentally opening the coffin of a person buried only a year before, was suddenly killed by a vapour that issued from it. In the same year too, he mentions, that there arose a vapour from the coffin of a person recently buried, during the time of a funeral, and of 120 persons who.

were present, 114 took ill of a putrid and venemous fever. A similar occurrence took place in West Linton some years ago: a school-boy getting into a new-made grave, set about to open the projecting corner of a coffin, which, as soon as he had penetrated, there issued from thence a strong nauseous smell, on which he exclaimed he was suffocated; he revived, on being taken out of the place, but fell immediately ill of a petechial fever, of which he died on the seventh day: and by this means, a similar fever was communicated to some of the people who had attended him during his illness. Sir John Pringle gives an instance of a severe malignant fever, with sunk pulse and stupor, having occurred in the ward of an hospital, where a man lay ill of an extensive mortification of his limbs. These fevers seem to have been occasioned by the respiration of a gas of a nature similar to that which the grave-diggers employed to clear the burying grounds belonging to the Church of the Innocents at Paris, were so cautious in avoiding, and of whose deleterious effects they gave many instances, to the physicians sent by the government to superintend the operation. It is likewise extremely probable, that a vapour allied in its properties and effects to this gas, gives occasion to the frequency of typhus amongst people exposed to the effluvia arising from putrefying animal and vegetable matters; as in the narrow lanes of crowded cities, farm-yards, burying grounds, and some manufactories.

The plague that desolated Europe, but especially Italy, in 1348, is said to have been occasioned by vapour rising through crevices in the earth. Arnoldus de Villa Nova records the history of a pestilence, that arose in his time, in consequence of the sinking in of a mountain near Naples, from whence there issued a loathsome odour, and swarms of disgusting insects and serpents. But disorders resembling the very worst forms of epidemics, have frequently appeared without the immediate application of one specified cause, but which seem to have been owing to the combined influence of several agents, and to be afterwards propagated by the emanation of a peculiar matter, generated in the course of the disorder. In this way, fevers of the most malignant description are generated on shipboard, in jails, hospitals, besieged towns, and in every situation where people are much crowded: these originate, in the first place, from want of fresh air, over-exertion, inactivity, sloth, and bad diet. In such circumstances, the effluvia that is continually rising from the bodies of men becomes accumulated, and of consequence its constituent parts form new combinations, highly pernicious to health. From this cause, Diodorus Siculus records an instance of plague or pestilential fever having broken out in Athens during a siege, the bounds of the city being too confined for those who, with their moveable property and cattle, had taken refuge in it: there are also instances of similar disorders being generated, in similar circumstances, in every remarkable siege; and we refer to the writings of ancient and modern historians, and to the general works on this branch of medicine, for other melancholy proofs of the same nature. But the following history affords a proof so remarkable of the power of concentrated effluvia in producing even the plague itself, that it merits particular attention. In the course of the 17th century, William Schouten, a Dutchman, while prosecuting his voyage to the East Indies, was driven considerably to the southward of the Cape of Good Hope, where he met with excessively stormy weather; his crew were quite overpowered with fatigue; in a few days, fifty fell sick of an ardent fever, which was soon followed by one of a contagious nature, which speedily affected the whole crew, and carried off more than forty men in the space of two days; their heads became considerably affected in the course of the disease: the other symptoms are detailed thus: "On leur voyait sortir le pourpre, avec le bubon, le charbon, et tous les symptoms de la peste; quelques uns sangnait du nez, sans en reçevoir aucune soulagement; la fureur s'emparait d'une partie des malades, les portait jusques à vouloir se tuer eux-mêmes; les autres se jettaient à la mer, quand ils pouvaient s'échapper."

From the above instances, it will be readily understood, that the primary cause of epidemical diseases is frequently the consequence of the co-operation of various agents, whose action is in the first instance confined to a limited space: but it frequently happens, that the distempers produced in consequence of those, generate in their course a matter which is capable of propagating the same variety of distemper, at any distance from the original source. This matter, though only evident to the senses in a remarkable degree, by its pernicious effects, is what is known by the term contagion. By the virulence of accumulated exhalation, we can likewise comprehend, how many people ill of a sporadic or endemial disease, frequently give origin to a different disorder of a regular and defined description, which is afterwards propagated by the evolution of its own peculiar matter or contagion.

Dr Chisholm (as well as many other modern writers on this subject) gives a remarkable history of this effect, in his Treatise on the Yellow Fever: and it is a circumstance of the highest importance, to be attended to by every physician in forming an opinion regarding the nature of febrile diseases, prevailing at the time. When a regular febrile disorder breaks out in isolated situations, and continues to be succeeded by other cases of similar symptoms, without being communicated to the attendants of the sick not exposed to the same causes; it will in every instance be found, that the disease arises in consequence of some local cause, and is to be considered as a local or endemial disorder; but if the fever puts on a new form, or has its former symptoms aggravated, and especially if it is not limited to a certain place, it may generally be relied on, that it owes its origin to a specific poison, whether this has been generated in consequence of the improper treatment of an endemic disorder, or from the virulent properties of accumulated exhalation, or other similar causes. And it will be afterwards more distinctly shown, that even the plague breaking out in places favourable for its production, where its foreign origin cannot be traced, most probably commences as a fever depending on local causes, by these either becoming aggravated in their nature, or by having the influence of other morbific agents superinduced.

The proofs of the existence of a peculiar matter, as being the cause of epidemic diseases, which we are enabled to draw from the foregoing statement, are as follows:

1st, It has been ascertained, that no change of the ordinary physical or chemical properties of the atmosphere takes place in countries during the prevalence of pestilential diseases.

2dly, The occurrence of epidemics is not prevented by the succession of seasons, nor by remarkable changes of weather; the plague, influenza, and other epidemics, having been observed to prevail for years, without suffering any abatement of their virulence.

3dly, That although it be admitted, that some of the most malignant species of epidemics arise from causes that are not originally of a contagious nature, yet this circumstance appears to be already sufficiently explained, as being the consequence of the malignant nature of those causes having previously propagated a disease, which in its course has generated a matter capable of producing a certain definite train of symptoms, at any distance from its original source; and it is owing to this peculiar circumstance, that it is frequently observed, that the diseases occasioned by contagion very often do not resemble those in type by which the contagious matter had been originally produced.

The sources from which matters arise fitted to occasion epidemic diseases, are so many and so various, that probably but a few of them are hitherto discovered; the mode of their action being, however, in every instance known to be similar, they may therefore be included in one or other of the following orders:

1st, The cause, perhaps, most immediately inimical to the living body, is the effluvia arising from the putrid remains of animal matters in a certain state of decay. This virus is always in the form of gas, and has its force seemingly concentrated, by being kept in contact with matters from which it has emanated. It is to the effects of this gas, that people incautiously respiring it, as grave-diggers, are sometimes suffocated in places where it abounds. In a less virulent degree, either in consequence of the state of the weather, or other circumstances, it occasions epidemical fevers, &c. It is doubtful, whether the effluvia arising from decaying vegetable matters, mixed with the former, adds any thing to its virulence: a contrary opinion is rather to be inferred; the gases which are produced in the putrefaction of vegetables being in some respects different from those which proceed from animal bodies during the same process. However, there can be no doubt, that when these are united, by means of a certain quantity of aqueous vapour, as in the exhalations from marshes, that very dangerous diseases are produced; and it is generally in consequence of the influence of animal and vegetable effluvia combined in this manner, that the greatest part of the endemic diseases of tropical climates are to be ascribed.

The second source that gives rise to matters which produce general epidemic diseases, is an accumulation of the usual exhalations from the living body. These being confined within a limited space, enter into new combinations, generating a matter of the most noxious properties. This appears likewise in an aëriform state; and there are frequent instances of it having almost instantly deprived people of life. This appears from the relation we have of the Black Assize at Oxford, and the dreadful sufferings of those confined in the black hole at Calcutta. It is probably owing to the co-operation of this and the former causes, that epidemics of the worst species are generated; and, except in a few instances, this perhaps never acts alone: and when combined with other causes, the plague is even generated in places otherwise favourable for its appearance. The contagious diseases that break out in besieged towns likewise appear in consequence of their union. At the same time, there is every reason to suppose, that this cause also frequently acts as a solitary agent. In this way, it is to be considered as the cause of an endemic or local disease.

The third and most pregnant source of epidemical disorders, is the matter which arises from a person labouring under certain diseases. It seems more correct, to consider this variety of the causes of epidemical disorders as the matter to which the term contagion is strictly applicable. Every epidemic or contagious disorder can be propagated from this source: the former have only a local influence. It is to contagion alone that certain specific diseases are produced, as small-pox, scarlet fever, typhus, plague, &c. All diseases that are propagated by the exhalation arising from a person labouring under any particular distemper, may have the same disorder communicated by inoculation. Contagion probably propagates its effects in the form of gas, though, from its seeming great affinity for other matters, it may have a similar power when united with them in a state of greater density. The manner how contagion is generated in the living system is still unknown: it is sufficiently obvious, however, that the state of our secretions must be continually changing in a certain degree, from diet, exercise, passions of the mind, &c. These alterations must appear most remarkably in people labouring under disease, and where the causes engendering it are of such power as materially to change the proportions of the constituent parts of the fluids: in this manner the evolution of a specific poison is effected. As a great proportion of the matters eliminated from the system, whether in a state of health or disease, is excreted in the form of vapour, and must at all times partake of the general mass from which they are evolved, the admission of any portion of them into the healthy system will naturally produce a similar train of symptoms as if they were introduced artificially; and they will thereby induce appearances in every respect similar to those which the person laboured under from whose body they emanated. The susceptibility of its impression must be regulated by constitution, habits, and climate; it being from one or other, or a combination of the whole of these causes, that particular exceptions occur during the prevalence of every epidemical disorder.

This is the opinion entertained by the celebrated Cullen respecting the cauſes of contagion, in the first volume of his First Lines. "We have supposed that miasmata are the cause of intermittents, and contagion the cause of continued fevers strictly so named, but we cannot with propriety employ these general terms. The notion of contagion properly implies a matter arising from the body of a man under disease, and that of miasmata a matter arising from other substances. But as the cause of continued fevers may arise from other substances than the human body, and may, in such cases, be called a miasma, and, as other miasmata also may produce contagious diseases, it will be proper to distinguish the causes of fevers, by using the terms marsh or human effluvia, rather than the general ones of miasma or contagion."

The above opinion seems also to accord with the explanation given of it by the celebrated Fracastorius: speaking of the distinction between infection and contagion, he remarks, "Qui hausto veneno pereunt, infectos quidem fortasse dicimus, contagionem accepisse minime; nunc si licet aliquo modo contagionis rationem subfigurare, dicemus contagionem esse consimilem quandam misti secundum substantiam corruptionem de uno in aliud transeuntem, infectione in particulis insensibilibus prima facta;" and in another place of his works, he states the following opinion, in discussing the nature of certain febrile diseases, "Contagiosæ autem vocantur non quæcunque vicinum et contiguum humorem possunt inficere; sed illæ solum quæ in alium consimilem infectionem conferre valent," a distinction which has been approved by subsequent observations. Perhaps the above doctrine is farther illustrated by finding that the bodies of those who have died of epidemical fevers, rarely or never propagate the specific complaint to those much exposed to its influence from this source. Thus, the dissection of those dead of plague rarely or never causes the communication of that disease to the operator. Immediately after, but commonly previous to the extinction of the vital spark, the various principles of the body, but especially those forming the humours, most likely begin to assume new combinations, which, though unequal to the support of life, must be different from the combinations which have taken place during the previous course of the disorder, in consequence of the impression of the morbific cause, and, by the influence of which, it has been experienced that a train of symptoms similar to those with which the person was affected may be produced, by a matter generated in their course being communicated to a sound constitution. When the system takes a tendency to recovery, it is probable that the power of perceiving impressions, and the changes of its principles, must be gradual, the operations of health insensibly counteracting those produced by the effects of the disease; whereas, the changes in the principles of the body on the loss of life, will be, in every case, the result of the commencement of their entire decomposition; and it is probable, that, on this account, the body of a person dead of a pestilential disease, will be equally incapable of producing a specific distemper, as that of a person who has died from any other cause. This circumstance will account for the above-mentioned fact, and at same time will enable us to explain why people, just beginning to recover from epidemical complaints, are more contagious than at any other period, except immediately preceding the crisis.

Having endeavoured to make it appear, that specific matters, capable of producing epidemic diseases, do exist, and their sources having been also pointed out, the general properties of these matters come next to be considered.

The very great subtilty of contagious vapour, and the difficulty of obtaining a quantity of it for examination, together with the danger that attends all experiments respecting an investigation of its properties, are the circumstances which have hitherto retarded our knowledge of its nature; it is therefore only by its effects that its existence is demonstrated; but this cannot be stated as an objection against its identity. Heat, light, and electricity, are only known to us in that manner.

Several philosophers, both in this country and in France, have bestowed much pains in their researches into the nature of contagion; but, unfortunately, the result of their experiments has not been attended with the success their ingenuity and perseverance deserved; it is probable, that the varieties of contagion will have a considerable effect in varying the result of every investigation of this subject. It has been discovered, that the fumes of acetic acid completely destroy the properties of contagious effluvia; sulphureous and muriatic acid fumes produce a similar effect; but the vapour of nitric and oxymuriatic acids have been found to possess the highest degree of antiloimic powers, and are least disagreeable when breathed.

These matters probably act in destroying the powers of contagious effluvia, by imparting to it a portion of oxygen gas: this opinion is rendered extremely probable, by finding that those acids act in this respect with an influence corresponding in degree to the facility with which they part with oxygen. From this it would appear, that their antipestilential powers are in consequence of an union effected between the contagious matter and the oxgyen gas they contain, by which the properties of the former are entirely altered.

It is to be presumed from these circumstances, that oxygen enters but sparingly into the composition of contagious vapour; an opinion which likewise appears to be confirmed by finding that this matter is entirely, or in greatest part, evolved from animal matters, into whose composition oxygen enters but in a small proportion. The composition of contagion, according to Fourcroy, for it is most generally regarded as a compound substance, is said to consist of sulphuretted and phosphoretted hydrogen gases, either in whole or greatest part; but it is not improbable, that most of the elementary matters of the body enter also into its composition, and that a peculiar matter is thereby generated, varying in its nature according to the number and proportion of matters composing it. But, in what this specific combination consists, or what particular difference in the union of its ingredients forms the varieties of contagious matters, remains at present seemingly an impenetrable secret, although its existence is declared by the varieties of epidemical diseases, and the evident difference of them from one another.

In the works of Dr Wintringham, a person of the name of Alprunus is mentioned as having examined the matter of a pestilential bubo by distillation; from which he obtained some phlegm, with a fat or oily matter, and a salt ascended into the neck of his retort; but the most remarkable circumstance in the experiment, was the unusual stench that issued from the vessels when opened, exceeding that of a thousand wounds exposed to the heat of summer, and a salt so exceedingly pungent as to equal the smell of aq. regiæ; appearances which seem to warrant, in a certain degree, the conclusion we have drawn respecting the particular combinations in the formation of contagious effluvia.

Contagion is not only communicated to a person in health, by being in contact with those labouring under certain diseases; but the contagious matter itself is frequently held in particular substances, thence called Fomites, which are no less powerful in propagating distempers similar in their nature to the diseases in the course of which the contagions they retain were generated; indeed, were it not through the medium of other substances, epidemical diseases must have been much rarer in their appearance, and, on their occurrence taking place, they must in that case have been extremely limited in the range over which they spread. In this point of view, it may therefore be concluded, that epidemical diseases are, in every instance, produced by contact only. Dr Cullen supposed, that contagions propagated by means of fomites, were more virulent than by approximation to a contagious person; but, if their powers are not increased in this respect, there are innumerable instances to shew that their force is by no means abated : as it is by fomites only that contagions are retained and propagated, these powers therefore require an attentive consideration.

There is an elegant and judicious dissertation on this subject by Fracastorius; he found, that the matters best fitted to convey contagion, are such as are least liable to undergo any alteration in their composition, in consequence of the affinity of the contagion to the body itself, or from the effects of heat or moisture, or the powers of the whole united.

The fitness of a substance for acting as a fomes, depends greatly on its degree of porosity; if the interstitial distances of its particles are either too large or too minute, it will not be so well adapted as matters whose interstitial foramina are of a medium size; in the one case, the admission of contagious effluvia is altogether prevented, and in the other it is more apt to be excluded by the atmosphere, or vapours of a different kind. It seems probable that contagion, properly so called, is the most frequent, if not the only matter with which substances are ever impregnated in becoming fomites. The effluvia arising from the first and second sources of contagion, appear rather to have their effects confined to the situations where they originate; the other may be transported to any distance, and, as will be afterwards shewn, proves active in every climate. From this idea of the qualities of a matter fit for conveying contagion, it may be presumed that woollen cloths, furs, cotton goods, *et similia*, are most apt to retain contagious matter; and it has been accordingly experienced, that they are capable of preserving it for years, and it has even then evinced the virulence of its nature to have been undiminished: from these facts, we are warranted to conclude, in the words of the judicious and eloquent Muratori, that contagion "non nasce come i funghi ne ha l'ali di volar lontano, si ne gliele prestano gli homini stessi." It is through the medium of fomites such as we have mentioned, that the contagion of plague is retained, and afterwards disseminated; it harbours about the clothes of people who have been near those sick of that distemper, and has been frequently sent off in bale-goods unknowingly long after every symptom of the disorder has disappeared from the place. The following instances sufficiently prove how tenaciously contagion adheres to that sort of matter, and cannot be too minutely attended to in regulating quarantine laws. The practice of shutting up, as done by the Europeans inhabiting countries which are most frequently visited by the plague, is generally successful, when all communication externally is rigidly prevented; but the following instance given by Volney, shews with what accuracy this must be attended to, in order to procure all the advantages that it is capable of ensuring. " Il y a quelques années qu'un chat passait par les terrasses chez nos negocians à Caire, et porta la pesté à deux d'entre eux, dont l'un mouroit." Considering the matter of contagion as possessed of peculiar properties, which can be propagated through the medium of other substances, the relation given by Forrestus may be repeated here, without any danger of its accuracy being called in question: he gives the account of a pestilence having been again excited by a person accidentally shaking and moving about some clothes that had been for some time laid up in a chest, and which had been impregnated with the semina of that disease. Zonini likewise mentions the case of a man who was suddenly killed by a vapour which issued from a trunk on opening it, on board a Turkish man of war having the plague aboard, as it lay in the old harbour of Alexandria in 1780; and, in the same way, the following case related by Fracastorius, will not appear so improbable as has been frequently asserted, on the suggestions of those who have entertained a different idea from the above respecting the cause of epidemic diseases. " Vidimus," says he, " anno 1511, quum per Germanos Verona teneretur, exorta peste, quæ decem millia hominum periere: ex una veste pellicea, non pauciores quam quinque et viginti Teutones obiisse, uno defuncto alius induebat vestem, et hoc alius, et alius donec monefacti e tot defunctis vestem combussere." Considering the known probity and accuracy of the author, and according to the view we have taken of the subject, there seems to be nothing in the above statement, that can be regarded as in the slightest degree derogatory to the credit of the narration; indeed, every one in any degree acquainted with the habits and thoughtlessness of the great body of military men, will most readily accede to the fidelity of the representation. This fact is rendered still more probable by another similar observation having been recently made respecting the contagious nature of cynanche maligna. Dr Brockelsby has shewn, that eight persons were successively attacked with cynanche maligna, by lying in a bed containing the contagion of that disease, and that too in spite of every means employed to purify it.

Green woods, fruits, and such substances, carry off immediate contagion, and are capable of conveying it to a certain distance; but the composition of these matters being so liable to change, they rarely harbour it for any length of time. Some have supposed, that by their fermentation the virulence of contagion has been increased; though it would appear, that its activity is sometimes altogether destroyed, by this process taking place in a mass of considerable magnitude. Wood that is perfectly freed of its juices acts as a powerful fomes, although, perhaps, it may be inferior in this respect to the matters we have already mentioned. Owing to the closeness of their pores and density, stony and metallic matters are not well adapted for carrying off contagious effluvia; and, when entire, they probably never do convey it, or at least but rarely: but, when in the form of powder, and especially if mixed with the remains of vegetable and animal matters, as in the rubbish of streets, &c. they then become well adapted for retaining the semina of contagious diseases. There is a paper in La Medicine Eclairée, giving an account of a great number of people having been inoculated with a gangrenous disease, in consequence of the puncture of some insects that had been near putrefying animal matters. Kircherus, Mercurialis, and others, have adduced similar instances of infectious diseases having been propagated by means of flies, who had been in contact with the original source of contagion, or had remained for some time upon matters strongly impregnated with it. Though it does not appear that contagion is frequently communicated in this way, it does not therefore seem improbable, that epidemical diseases may occasionally originate from this source; though the contagious diseases of cattle are perhaps most frequently propagated by them.

Besides the influence of such matters as we have mentioned as best adapted for conveying contagion, epidemical diseases have been supposed to be much oftener disseminated by means of the atmosphere itself, without the intervention of any other medium, and that it is to the impurities with which the air is occasionally mixed, that their varieties and general appearances are to be accounted for.

As there are many reasons for inducing us to believe, that contagion generally, if not always, exists in a state of vapour, its affinity for the atmosphere, like every other gaseous fluid, will not be called in question; and being mixed with it in considerable quantity, it may thereby be conveyed in all its virulence to a considerable distance; it is also extremely probable, that contagion exists in all sorts of fomites, united with a certain portion of the atmosphere. But whether it be owing to the affinity subsisting between these fluids being but slight, or on account of the immense disproportion between their volumes, and the continual fluctuation of the atmosphere, whereby the contagious effluvia becomes too widely diffused through it; it has been found, that the effects of contagion are never communicated through this medium to any great distance from its original source. Fracastorius imagined, that the air has a power of dissolving contagion, and thereby rendering it inert,—an opinion which Dr Haygarth has revived, and supported with many ingenious observations; and from what has been observed of the powers of several matters in destroying the virulence of contagion, it appears more probable, that the inactivity of this matter, when mixed with the atmosphere and conveyed to a distance, is in a great measure the consequence of a combination of some of the component principles of this medium with the contagious effluvia. Dr Russel's Treatise on the Plague affords a satisfactory illustration of this circumstance, by showing at how short a distance from a contagious person the exhalations from his body become inert, when mixed with the atmosphere. During the prevalence of a plague in Aleppo, for which he had shut himself up in the English Factory there, he was accustomed to give advice to crowds of people sick of that disease, who were brought under his window, which was only about fifteen feet elevated above the street. He remained in this station several hours every day, and the urine of his patients was often handed quite near to him; nevertheless, neither he, nor any of the other gentlemen of the same hotel who assisted him, ever experienced any bad effects from practising in this way.

Assalini remarks, that the French garrison at Cairo remained free from the effects of contagion, at the very time the plague desolated the city. This circumstance, however, is in some degree explained, by the relative situation of the castle and the town. Tavernier describes Grand Cairo as lying close under the hill of the castle, by which all wind and air is intercepted, which causes such a stifling heat there, as engenders many diseases. But this likewise affords a remarkable instance of the low degree of contagious power, when that matter is mixed with the atmosphere.

This is also the opinion of Dr Smyth; and he has made known the following observation respecting the contagious nature of the fever that prevailed amongst the Spanish prisoners of war at Winchester: he found, that "unless the contagion is very powerful, it is seldom propagated in the open air. I knew," says he, "only one instance of this at Winchester. It is much more certainly communicated in a room, and especially if there is a current of air from the contagious person to others capable of being infected." And in the course of the same fever he likewise ascertained, that "every species of contagion has its virulence lessened, and is at last completely effaced, by exposure to the open air." Many similar instances might be adduced in proof of the weakened power of contagion when mixed with the atmosphere. It is probably owing to this cause, that several cases of exemption takes place, as also the gradual manner that every epidemical disease spreads over a country; and it is likewise owing to this circumstance, that a great part of the measures of precaution inculcated by our quarantine laws are effectual.

This being the natural effect of the ordinary state of the atmosphere in destroying the properties of contagion, it will be likewise proper to investigate how far certain conditions of it, in respect to temperature or humidity, tend to the same effect.

Hot dry weather is unfavourable to the propagation of contagion: this is a fact well ascertained by writers on epidemical diseases, and is maintained unanimously by those who treat of the diseases of tropical climates. It has been with good reason supposed, that to this general state of the air in Egypt, the exhalations arising from the stagnating water left by the river in the pools and canals about Cairo, so very rarely produces any malignant disorder; and it is to this cause also, that the plague originates more seldom in that climate; though, in every other respect, circumstances are extremely favourable for engendering it.

Dr Blane found, that ships' crews affected with the itch on leaving England, got better of it, without any remedy, on arriving in warmer latitudes, as they proceeded on their voyage to the West Indies. It is also to be remembered, that exposure of infected matters to an high degree of heat, is the method generally employed to dissipate contagions from all sorts of clothes or furniture, and it has commonly been found effectual. The manner how a hot temperature of the air acts in lessening the virulence of contagion, is not satisfactorily known; probably it has a considerable power in this way, by rarefying the contagious effluvia, or by an increase of temperature, causing its principles enter more readily into different combinations, its particles being thereby separated to such distances, that the peculiar properties they possess in their entire state is lost. In like manner it is found, that a low temperature of the atmosphere is unfavourable to the propagation of contagion; it having been observed, that epidemic diseases rarely break out in the winter season of temperate latitudes; and it has been denied, that on this account they ever penetrate so far as the arctic circle. Nevertheless, neither of those positions is without exceptions: of the first we have already mentioned several authentic instances; and in the histories of the most remote northern countries, as of Siberia and Iceland, they appear to have been frequently depopulated by the progress of contagious disorders. It is probable, that cold acts by condensing contagious vapour, in this manner confining it near to the surface of the earth, by which it is probably prevented having access so readily to the organs through which its influence is propagated.

A humid state of the atmosphere has been found to annihilate contagion completely: in this way, the most virulent epidemics have been observed to stop after heavy rains, and to abate considerably after heavy dews: the copious dew that falls all over the sea-coast of Egypt, has been frequently experienced to destroy all the semina of an imported plague, and in this manner to prevent it getting beyond Alexandria. There is also a fact strongly corroborative of the efficacy of humidity of the air in destroying contagious vapours; it having been long known in the Levant, that a moist evening is of more service in clearing infected goods of contagion, than a month of dry weather. Schrieberus likewise affirms, from personal experience, that during rainy or cloudy weather, epidemical diseases appear to lose much of their virulence, and are not propagated so expeditiously. It would be of little importance, to accumulate authorities in support of an observation respecting which there does not exist two opinions: it will be therefore only necessary to mention, what has been taken notice of by almost every writer on the climate of Egypt, that the plague uniformly ceases in that country as the Nile begins to increase. This appears to be owing to the greater humidity of the atmosphere, in consequence of the larger surface of water exposed to evaporation; and likewise by the inundation of the canals through the country, the pestilent exhalations arising from them become thereby less noxious. It is not easily explained how this particular state of the atmosphere should prove unfavourable to the spreading of contagion, or what its precise effects may be in destroying its powers: were the humid air merely to act by dissolving contagious effluvia, we cannot perceive why a total alteration of its properties should thereby ensue. A solution of any substances, whatever is the menstruum, as common salt in water, or camphire in spirits of wine, always partakes of the properties of both substances. It is therefore not improbable, that in this case the watery vapour of the air acts by effecting a total change in the combination of the matters composing contagion, though humidity may also annihilate its effects, by combining with it in excessive proportion. Temporary changes in the state of the atmosphere have a most powerful effect in modifying the malignancy of prevailing diseases, whether these be endemic or epidemic: thus, contagions spread more rapidly at certain times, and even in the most temperate climates. Typhus, small-pox, &c. are observed to become more active in a dull foggy state of the weather; on the contrary, their progress is less rapid, when the atmosphere is warm and dry. Every writer on pestilence has remarked an aggravation in its symptoms, with a proportionate virulence in its contagion, about the time of full moon; and probably by an attentive observation, this may be found to be the case during the appearance of every acute disorder. The effect of the atmosphere in varying the appearances of diseases, has been remarked from the earliest antiquity: it is from having frequently observed this circumstance, that Hippocrates warns us to be attentive to the great changes of the seasons, particularly the solstices ; at these times, we should not rashly give medicine, nor change our dress for at least ten days before or after them.

But, although neither a humid nor a warm state of the atmosphere are separately favourable to the propagation of contagion; yet the conjoined influence of these conditions of the air, seem not only the states of it best adapted for the conveyance of this effluvia, but it appears to have even the power of thereby exciting, in other substances, the evolution of those matters which give rise to endemics of the worst species; at least this is the condition of the atmosphere generally observed where these are most prevalent. Dr Smyth remarked, that "a contagious person becomes greatly more so, if his clothes are wet, and his body heated by exercise, so as to be in a state of perspiration." This circumstance did not escape the observation of M. Volney while in Syria; and the following remark is strictly agreeable to general experience: he says, " L'hiver détruit la peste à Constantinople, parceque le froid y est très rigoureux; l'été l'allume, parceque le chaleur y est très humide, à raison des mers, des forêts, et des montagnes voisines. En Egypt, l'hiver fomente la peste, parceque il est humide et doux; l'été la detruit, parceque il est chaud et sec."

This effect of the atmosphere is of considerable consequence in a practical point of view: it being owing to this circumstance, that in tropical climates only, or in those in their immediate vicinity, the most dangerous epidemics take their rise: and it is likewise owing to this cause, that in such climates one season of the year is generally more healthy than the other, which in many instances has caused an arbitrary division of the year into the healthy and sickly seasons. In a hot moist state of the atmosphere, animal and vegetable matters run more quickly into putrefaction: it has been already observed, that matters unfavourable to health are generated from these sources, and which are seemingly possessed of a degree of virulence, in proportion to the heat and moisture of the climate: it is evidently owing to this cause, that the end of summer and autumn are the most sickly seasons in temperate latitudes.

The above appears to be the real power of the atmosphere in propagating epidemics; and by investigating the effects of its various conditions on contagious effluvia, it has been shewn, that it possesses this property in a very limited degree only, and that its supposed influence in this respect has been assumed from misconceived appearances. Had the power of the atmosphere, either as generating or propagating contagion, been considerable, epidemical diseases must have been then still more frequent; nor does it appear possible, that in these circumstances any natural means could have been suggested, of ever getting rid of them when once generated, and this world must of course have presented a barren untenanted surface.

There is a very curious observation, respecting epidemical diseases, which, in latter times, was originally taken notice of in a philosophical manner by Mr Hunter: he perceived, that two different contagious diseases will not exist in a person at the same time. This is daily confirmed in the case of small-pox and measles; and instances have even occurred, where the progress of local venereal complaints have been arrested, on the patient being attacked by fever. But there are observations which go farther in this respect; it having been remarked, that during the prevalence of a severe epidemic, other distempers entirely disappear.

In the first remarkable plague that desolated Athens, as recorded by Thucydides, this circumstance was observed: "Enimvero," says he, "annus ille ut confessione fere omnium constat, maxime immunis fuit aliorum morborum: quod si quoquis alio prius laborabet, is morbus in hunc omnino convertabatur." And we find, that Paræus has taken notice of the same fact; he having found, that every ailment partook of the nature of the plague, as that disease increased in virulence, and in this way every disorder was absorbed by it. In more modern times still, Dr Heberden has related a similar occurrence, which tends greatly to confirm the correctness of the observation : it was experienced in a town where agues were frequent, on the small-pox being introduced, that many who had the ague were seized with them, the intermittent stopping in the mean time spontaneously; the variolæ run their usual course, and as they went off the fever again returned. But although this may be generally the case in seasons when severe epidemics are raging, I have certainly seen measles supervene chincough, which no doubt in every instance became milder, as the former disease run its course; becoming equally violent when that had disappeared.

Were we once able to determine correctly, in what manner contagion is naturally introduced into the system, it would afford us the most effectual advantages in guarding against the attacks of epidemical diseases, which, together with the discovery of an antidote for their cure, compose the desiderata most wanted in this branch of medical practice. There are many opinions entertained on this subject, and all of them espoused by men of talents, and consequently supported with plausible arguments: the stomach, the skin, the lungs, and impressions on the nerves, have each their abettors, as being the organs through which contagion is communicated to the circulating fluids.

Fracastorius, who has written the most distinct treatise on contagion that has yet appeared, seems doubtful whether this matter does not find access into the system by means of the veins and arteries on the surface, (he probably means by absorption): but at the same time he imagines, that this poison gets most frequently admission into the blood, by the air in inspiration, and that it then acts by assimilating the humours to its own nature. Dr Darwin does not admit, that contagion affects the system in any other manner than through the medium of the intestinal canal. This opinion appears to be corroborated, by the disturbance that always takes place in the functions of the stomach, in the course of fever, but especially at its commencement; and that this symptom is aggravated, nearly in proportion to the violence of the fever, and the power of the specific cause producing it. This is likewise the opinion of Dr Lind, and other celebrated physicians. However, it does not appear, that even when the atmosphere is strongly impregnated with contagious effluvia, and that a quantity of it then mixes with the saliva, and is carried down to the stomach, that there is any good reason to suppose its influence there would be productive of any specific effect. We are certainly warranted to suppose this would not be the case, from what is known of the functions of the alimentary canal, and likewise by the experiments of Fontana on other animal poisons, whereby it has been ascertained, that no pernicious consequences arise from their application to those organs in a healthy state,—an opinion which receives perfect confirmation, by the instance given by Mr Hunter, where it was found, that a quantity of venereal virus was inadvertently swallowed by a young lady, without any bad consequences having followed. At the same time, a degree of sickness and a transitory local affection may be the consequence of the admission of contagious vapour into the stomach, in the same manner as Dr Ferriar supposes contagion may be propagated, by a direct impression on the (olfactory) nerves. Dr Hunter, in his work already mentioned, relates a case, which he imagines shews, in a decided manner, that contagion enters likewise by the lymphatics on the surface: "An elderly woman, with an old sore on her leg, was subject to fevers, which held her several days; they were preceded by pain and swelling in the groin of the side on which the sore was, and there were lines observable on the skin, running from the sore to the groin, the marks undoubtedly of the poison passing through the lymphatics." In this case there is evident proof, that a fever was occasionally excited by the absorption of matter from the surface of the sore; but the relation of the case certainly implies, that the matter was generated in the sore itself; and there does not exist a shadow of proof, that this matter was contagious, and was taken up from the atmosphere, or from any other source of contagion. There is an immense variety of matters that may be absorbed in a similar manner, and occasion a like perturbation in the functions of the body; but this by no means implies, that they are all, or even any of them, of a contagious nature.

In the above case, we are not informed if this fever was in any instance communicated to the patient's nurse or other attendants: if it even did so with ordinary care, we may safely venture to assert, that it stands in opposition to the observation of every author who writes on contagion from his own experience. Indeed, from what has been already mentioned when treating of the influence of humidity of the atmosphere, it does not seem probable, that contagion ever gains admission into the system, through the cuticular lymphatics.

Fernellius has stated his opinion on this question in his usual style of elegance and perspicuity: he says, "Venenum — quod halitu nos ferit, celerrime per pulmones in cor viscus nobilissimum, et in arteriis, in omne denique corpus irrepit, primum spiritus, deinde humores, postremo substantiam ipsarum partium labefactat:" indeed, in this sentence, he gives an account of this particular theory, in terms no less eloquent and clear, than the present improved knowledge of the animal economy could admit of. This theory, of which he, from many circumstances, may be regarded as the author, is, in several respects, to be considered as the most accurate and the best supported by facts and analogous observations of any that has yet been proposed on the subject. Dr Moseley says, he always experienced a shivering, like an ague fit, in crossing the Pontine fens before day-break near Terracina; and he likewise felt the same sensation in the neighbourhood of the naval hospital at Greenwich, Jamaica. But Sir John Pringle and Dr Lind give still stronger proofs, that the immediate cause of fever is taken in by the lungs: they relate instances of people, on being exposed to the exhalations arising from marshy grounds, becoming even suddenly delirious, and continuing so till the fever had run its usual course. Dr Smyth has made an observation, which has been repeatedly confirmed, that a moist air, in certain circumstances, is more favourable to the propagation of contagion than a dry one,—a fact which seems to prove, that contagious effluvia impregnated with moisture in this way, finds a more direct introduction to the lungs, and is thereby more readily absorbed.

The opinion that contagion is received by the lungs, seems likewise probable, by finding that a peculiar smell is almost always experienced at its source: besides, this contagious odour has been frequently perceived so disagreeable and strong, that there are many well-attested instances of sudden suffocation having been occasioned in consequence of inspiring it. The subsequent quotation from Pugnet's Mémoires sur les Fievres, &c. p. 183, at once affords a striking illustration of the existence of contagion, and of the opinion we have endeavoured to establish respecting the mode of its admission into the system. "Le 3. Floreal, en entrant dans le lazarette, pour faire ma visite, je rencontrai un malade qui venait d'y être introduit, et que deux servans transportaient. Je le suivis pas à pas, jusques à l'appartement que lui était destiné. Au moment ou la porte de cette salle fut ouverte, un courant d'air très fort passa de lui à moi, et je me sentis comme suffoqué. Je ne sçaurais dire ce que me fatiguait le plus, ou une extreme difficulté à respirer, ou un vif sentiment d'irritation que je éprouvais dans l'arriere-bouche, ou des douleurs vagues qui établirent tout-à-coup leur siège dans mon estomac." The above opinion receives some farther confirmation from analogical facts: thus, a degree of intoxication frequently, or rather always, takes place in some measure in people employed to decant off large quantities of vinous spirits: indeed, the instinctive repugnance which every one experiences in breathing disagreeable odours of any kind, affords a strong presumption that these are pernicious by being inhaled with the atmosphere. It has been likewise observed, that people affected with chronic pulmonary complaints, as phthisis, asthma, &c. and new born children, who vitiate the air less than others, are not so liable to be affected with febrile contagion.

Every physician much versant in the cure of the venereal disease, must have occasionally met with cases, where children were born with that complaint a considerable time after the mother has been perfectly cured in the course of her pregnancy.

There is a young man, with whose history I am intimately acquainted, and of whom there is the most convincing reasons for believing that he was born labouring under the effects of small-pox contagion. There was perceived at his birth, in different parts of his body, but chiefly on his breast and neck, several pustules nearly maturated, and having every appearauce of being variolous: these continued till fully maturated, and then disappeared in the usual manner of that disease. For some weeks previous to his birth, the small-pox had been epidemic in the neighbourhood, and two or three people of the family had been ill of them. His mother had the small-pox in the natural way during her infancy; and she was not sensible of any illness or unusual disorder during her pregnancy. The young man himself has been repeatedly exposed to the contagion of small-pox in every way, without ever having had the slightest symptom of the disease.

It is not meant that these cases afford a direct proof, that contagion enters by the lungs: but, as they shew evidently that this matter can be communicated from the mother to the embryo; and, as there are very cogent reasons for supposing, that the placenta performs a function to the fœtus analogous to the office of the lungs in respiration; we are therefore induced to think, that there exists a corresponding similarity in both instances respecting the manner in which contagious matters get admission to the system. And this opinion seems to receive additional proof, by the frequent abortions that occur in women during the prevalence of pestilential disorders, as observed by every writer on such distempers.

The space of time that intervenes from the reception of contagion into the system, till its effects become manifest, is not determined with certainty; probably, each variety has a period peculiar to itself; at least we are warranted to make this conclusion, from what is observed to take place in infectious disorders or inoculated contagions. The determination of this question is of the greatest importance for individual preservation, and is a point on which the quarantine laws might be more judiciously regulated. At present, forty days is the time to which the quarantine restriction extends in this country: but it is the opinion of Muratori and others, that twenty days are quite sufficient for this purpose in the contagion of plague, but that the person performing quarantine, should, during that period, be made to change his situation frequently, so that his constitution may not become too much habituated to one place, and therefore shew no signs of disorder, when the air he breathes is even greatly loaded with contagious vapours. Without this precaution, he justly observes, that forty days are even too few to prevent the recurrence of the disease. From these observations, we cannot therefore give our assent to the opinion of Dr Arbuthnot, who says, " I think it probable, that the Turkish contempt of the contagion does not propagate the disease more than the Christian dread of it." But were this opinion accurate, quarantine regulations would be in no instance of any avail; besides, were the attention of the Mahomedans in preventing the concurrence of causes, which give rise to the plague in warm countries, and if their care of preventing its spreading after it has broken out equal to the Christian vigilance in this respect, we might hope to see this scourge banished from the earth. The few data that can be acquired to ascertain the exact period of admission of contagion, during the prevalence of a general distemper, will effectually prevent accuracy in settling this point, as it will probably be protracted or hastened according to the virulence of the contagion itself, and the susceptibility of the person exposed to it. A certain variety of contagion is at one time long in shewing its effects, while in other instances it exerts an almost immediate power; but, as has been already observed, constitution, habits, and season, will act a considerable part in varying this period. The semina of plague have in some instances caused sudden death: on other occasions, they have been supposed to remain inactive during three, four, and even six weeks; the first being by no means an uncommon period, but probably their attacks are most frequently manifested within eight days. Typhus, and every fever of that type, corresponds in this respect with plague. Eruptive diseases are supposed to appear earlier. Confluent small-pox has been known to appear within twenty-four hours after exposure to contagion. But there are instances where both animal and vegetable poisons have evinced their activity, after adhering to fomites for a considerable lapse of years. In this way, the venereal disease has appeared at the end of eight years; and small-pox has been propagated in like manner after a lapse of thirty years: and it is likely that these and other contagious effluvia may be preserved in full vigour for a much longer time. For a more complete investigation of this part of the subject, we refer to the works of Van Sweiten, Dr Haygarth, and almost every writer on epidemical diseases.

Two different opinions have been maintained, respecting the mode in which contagious effluvia affects the living body; it having been imagined, that its effects are such as arise from the impression of a sedative or directly debilitating power on the nervous system; while it has been supposed, with no less probability, to have produced all the phenomena in consequence of a directly stimulating property. The latter opinion seems to accord better with similar appearances in fevers, which take place from the application of powers known to possess this quality; as from over-exertion, debauchery, and in general such as arise every where sporadically. It is extremely difficult, if not impossible, to trace the line between matters possessed of a sedative power, and those of an highly stimulating nature, their effects being in many instances apparently similar. But on considering the variety of contagious disorders, and the increased action of the system that uniformly takes place in them, there can be no hesitation in referring their causes to the latter class. This opinion seems still more probable, from the time that usually intervenes from the admission of contagion into the body, and when it begins to manifest its effects; as, were its nature of a sedative quality, a quickened circulation, with an increase of temperature, could hardly be expected. In every fever, but especially in those which originate from contagion, a confusion of the sensorial functions is always a prominent symptom, and is more remarkable in bad fevers at their commencement, which has been supposed to indicate, in the clearest manner, the sedative nature of their causes. But it seems more readily to admit of explanation, as an irregularity occasioned by the impression of a stimulant power; and the phenomena that take place in the course of every contagious disease, before re-action has debilitated the system, tend to confirm this opinion; for were these occasioned by a sedative power, the re-action of the system must have been weakest at the commencement of the fever: and, as far as we are able to judge from the practice inculcated by the most experienced physicians in this class of diseases, this seems to have been the opinion entertained of the nature of their causes in every age till the present.

We should next proceed to deliver an account of the methods that have been suggested as most effectual in preventing the direful effects to which contagion gives rise; but there are still some circumstances of considerable interest in this discussion, which deserve to be investigated, as tending to a more successful practice in certain varieties of epidemics, and which will serve also to illustrate the doctrine delivered in the former part of this essay.

It has been assumed, on the authority of Herodotus, that in early times the plague was not experienced in Egypt; but it must be remarked, that this writer cannot be esteemed of sufficient weight to determine that opinion, because he makes no mention of the particular diseases of that or any other country whose history he treats of. But allowing that he had expressly denied the existence of that disease in Egypt, we have still a better authority to the contrary, in the Book of Amos, where it is said to the Jews, by command of the Deity, " I have sent among you the pestilence, after the manner of Egypt,"—a most unquestionable proof that this disease must have been common in that country even in the most remote ages. Indeed, no one can contemplate its geographical situation, and the natural circumstances of its climate, without being impressed with the opinion, that plague must have been at all times an affliction to its inhabitants, though probably it did not appear so frequently in former times as at the present day. The Egyptians were originally an active well-informed people, and their internal police was the admiration of surrounding nations; but through a long succession of ages, they have been repeatedly forced to yield to the yoke of more powerful opponents, and they are at present sunk into the most wretched state of sloth and superstition; consequently, the whole of those precautions which were formerly so minutely attended to, are now utterly neglected; and their numerous canals and lakes, which in former times were so conducive to the salubrity of the climate, in the present day are frequently found to emit the most pernicious exhalations, and thereby tend to its contamination. It follows from this circumstance, that any endemial or epidemic malady will spread more generally, be more violent in its effects, and will be more difficultly eradicated from amongst the present inhabitants of that country, than from amongst a people of the former habits. From these and other circumstances immediately depending on the climate of Egypt, plague must have been much less frequent than in other places in its vicinity. The superior healthiness of the air of that country has been remarked from the earliest æra down to the present time; and it is owing to this property of its climate, that plague has been generally affirmed to be an imported disease there. On this subject, Alpinus says, "Ex tribus vero locis præcipue pestis in Egyptum accidit, scilicet ex Græcia, Syria, et Barbaria, quæ autem ex Græcia, et Syria illic vehitur, Cayrumque corripit satis mitis et minus fera; pauciores homines interimere observatur, brevique tempore tollitur; sed quæ ex barbaricis locis in eam urbem invehitur, omnium est perniciosissima, sævissima, longissima, plurimos populos depascens, atque stragem multum ipsis inferens." M. Volney, and other writers on the climate of Egypt, likewise affirm the same thing, and that it is imported in the robes and furs of those who have died of plague in other places, and are thence carried into that country for sale. Volney says, "Nos négocians établis depuis longues années à Alexandrie, assurent de concert avec des Egyptiens, que la peste ne vient jamais de l'interieur du pays: ils observent, qu'elle est toujours précedée de l'arrivée de quelque batiment venant de Smyrne ou de Constantinople."

But though it be admitted, that the plague is most commonly carried into Egypt, yet, considering the filthy habits of the people, and that it is so liable to be covered with water left by the river, stagnating under a burning sun, and filled with decaying animal and vegetable remains, it will hardly be doubted, that diseases of the very worst description will be occasionally generated in that country. And accordingly, every writer on the climate of Egypt has remarked, that the endemic fever originating from this cause, and which is so frequent on the coast, particularly about Alexandria, becomes occasionally so virulent, that it cannot be distinguished from the true plague,—an admission which certainly confirms the opinion, that this distemper may be sometimes generated in that country, and, as the elegant and learned Volney supposes, a similar co-operation of causes on the American coasts frequently breeds the yellow fever in the United States. This is decidedly the opinion of M. Pugnet, formed from actual observation in Egypt, he having accompanied the French expedition there as physician to the army. However, in speaking of the importation of the plague into Egypt, Volney says, " Que sa vraie foyer est à Constantinople; qu'elle s'y perpetué par l'aveugle negligence des Turcs: elle est à point qu'ils vendent les effets des morts pestiferés : les vaisseaux qui viennent ensuite à Alexandrie, ne manquent jamais d'apporter les foureurs, et des habits de laine, qui sortent de ces ventes, et ils les debitent au foyer de la ville, ou ils jettent d'abord la contagion."

The Baron de Tott bears witness to the accuracy of this statement: the Baron says decidedly, that the focus of the plague is always in Constantinople; that its semina are not only preserved there in the manner pointed out by Volney, but the cause of the disease itself seems to be generated in that city; this arises in consequence of the general habits of the people, and the total want of cleanliness and propriety in the streets of the city. The plague is therefore continually engendered in that place, from the operation of the same causes which produce it every where else. It is observed, that the plague never breaks out in Constantinople in the houses of the opulent, or in such as are kept clean; and it prevails principally, and at all times, in the lodgings of the lower orders, which are generally kept in a state of excessive filthiness; the narrow confined streets are in no better order, and are generally strewed with the decaying remains of animal and vegetable substances. Such being the condition of a great part of that city, and considering the temperature of the climate, it is not to be wondered that it should never be free of plague in some quarter or other. By these observations, we find the reason why the plague was much rarer in Egypt in former times, than since the foundation of Constantinople, but especially since it has fallen under the dominion of the Turks; and its appearance there must likewise have become more frequent in consequence of the melancholy changes that have taken place on the face of that country, and from the degenerate manners of its inhabitants.

It has been asserted by Dr Blane, that the plague never appears in tropical countries, nor in latitudes within the polar circles, and that its appearance is confined to the temperate zones of the earth between latitudes 40° and 60°. But, in opposition to this opinion, there are many well-attested facts: the existence of the plague in Egypt is even a proof of its incorrectness; and it is generally admitted, that even the most malignant varieties of typhus break out in countries within a few degrees of the line. There is the respectable authority of Thucydides on this point: when speaking of the origin of the plague which ravaged Attica during the first Peloponnesian war, he says, "Incipit autem primum (ut fertur) ex Ethiopia, quæ est super Egyptum, deinde in Egyptum, Lybiamque descendit." We have already quoted the testimony of Alpinus on this question, who expressly affirms, that the plague frequently visits Egypt from Barbary, and that it is then always more virulent. On the credit of the Papal Missionaries, Hoffman likewise observes, that the pestilence is frequent in the island Formosa; and it is probable, that this disease must be also frequently prevalent in the adjacent countries. In corroboration of the same fact, we have the testimony of Petrarch, repeated by Mezeray, Muratori, and Mead, who describes the plague which depopulated Europe in 1349, as having originated at Cathay in 1346; from thence it spread over the East Indies, Syria, Egypt, and Africa, and from the coasts of that country was brought into Sicily and the rest of Europe. Pliny likewise remarks, in his 7th book, "Quæ in re observatum, in meridianis partibus, ad occasum solis pestilentiam semper ire;" and it has been observed, that diseases of a pestilential and contagious nature have prevailed even within the arctic circle. There are also many symptoms occasionally met with in the contagious yellow fever of the West Indies, similar to those which characterise the plague in temperate climates; and in fine, it has been repeatedly observed, that the plague is frequently brought with the caravans from the interior of Africa. From what has been already said of the circumstances most apt to engender the plague in Constantinople and Egypt, it will be readily understood, that the same distemper will originate wherever a similar arrangement of these causes does occur; and this is certainly more frequently to be met with in a warm climate than in temperate latitudes. Considering all these circumstances, there does not seem to exist even a probability for supposing that there is an exemption from the contagion of plague in any climate, although in some it must be much more active in its powers than in others.

There is an endemic fever frequent over the coasts of the Levant, usually of a remittent form, and, according to the description given of it by Alpinus, it is more severe during one season of the year, and agrees exactly in its symptoms with the endemial fever of Batavia, America, and the West Indies, being occasioned by the operation of similar causes in a climate nearly the same. It has been frequently perceived so virulent about Alexandria, that it acquires all the appearances of the most inveterate plague: in the same way, the endemial fevers of every situation become occasionally so aggravated, that they cannot be distinguished from such as originate from contagion; and, in every unusual virulence of this endemic fever, it is probable that it is augmented by the increased energy of its usual causes, and that it may be propagated afterwards by contagion, as every epidemic. Dr Chisholm gives many melancholy instances of the justness of this opinion; and it is to be presumed from the facts recorded by several writers on the plague, that it has frequently originated from this cause. Volney found the endemial remittent fever of the Levant terminate frequently in obstructions of the liver, though it is not so often accompanied with a yellowness of the skin as in that of the West Indies. In some seasons, about Alexandretta, even a third of those affected has been known to die of it.

In the histories of the plagues treated by Diemerbroeck, Sydenham, Russel, and others, it was uniformly observed, that a malignant fever was the precursor in every instance, and that it gradually became more malignant as the plague introduced itself, till at last it became absorbed in this more prevalent distemper. From the accounts given by authors on the same subject, who have lived at very distant periods from each other, it is found, that the plague gradually disappears, becoming milder in its symptoms, and assuming the more gentle form of fever.

The very general yellowness of the surface of the body that takes place occasionally in every fever in the West Indies, has led many to mistake the endemial causus of the climate, for another fever produced by a cause very opposite in its nature. The latter fever has many symptoms, especially at its commencement, that generally afford marks which distinguish it from the former; though on other occasions, the diagnostics are by no means well defined. It seems now to be fully ascertained, that both the remittent and intermittent fevers of the West Indies, are accompanied with a yellowness of the skin and eyes, when they appear more severe than common: these take their rise independently of contagion, and probably owe their appearances to the varied effects of the same cause, occasioned by peculiarity of constitution or other circumstances. It is likewise understood, that there is a frequent occurrence of typhus in several of the islands, which is uniformly marked with the diagnostic sign of a yellow skin, but whose symptoms are evidently occasioned by contagion: this is decidedly shown in the work of Dr Chisholm on this subject; and the existence of this species of fever in that climate, is likewise maintained by Desportes and others. It is difficult to designate the precise manner how this contagion has originated in every case; but it has been already shown, that a similar disease may, and frequently does occasionally arise, from an unusual malignity of the causes of the common fevers of the country, or from improper treatment of them or neglect. In the case of the typhus of the West Indies, it has been agitated a good deal, whether or not its appearances there may not be owing to a cause foreign to the climate; some having supposed, that it originated in consequence of a contagion imported from the old world; it having been perceived, in many instances, with symptoms strongly resembling the plague: the following observations are accordingly subjoined, as an elucidation of this question.

It is to be observed in the history of the typhus flava of the West Indies, that Pere Tertre, an apostolic missionary, who lived in the islands of St Christophers, Guadaloupe, and Martinique, from 1640 to 1648, gives a very minute account of the natural history of these climates, but makes no mention of a contagious fever existing in them, though he is otherwise very particular in the description of a fever, which he says was ordinarily met with in that country, but which does not appear to have proved uncommonly mortal, or to have been accompanied with a yellowness of the skin. As he takes no notice of either of these circumstances, it is to be presumed, that the yellow fever did not then exist in the West Indies; this has been therefore regarded as an indirect proof of its foreign origin. Desportes supposes, that it was brought from Siam to St Domingo in 1734; and according to this opinion, the contagious yellow fever is generally called by the French colonists, "la maladie de Siam." According to Warren, this fever first made its appearance in Barbadoes in 1721, and he endeavours to trace its origin to the coast of Asia, on very distinct authorities: he says, it was brought in bale goods from St Jean d'Acre to the port of Marseilles, from thence to port St Pierre: this account was confirmed to him by a Mr Nelson, an English surgeon, who died of the fever in that island. Nevertheless, Hillary opposes this opinion, and with some others affirms, that yellow fever is indigenous of the West Indies: but certainly this is by no means countenanced by the observations of early writers on that climate.

Don Ulloa relates, that the yellow fever first made its appearance in that part of the world, some time about the commencement of the last century: and Hughes, who was not a physician, knew a Dr Gamble who remembered it in Barbadoes, so long ago as 1691; it was then called Kendal's fever, the new distemper, and pestilential fever,—names distinctly indicating the notions entertained of its origin and type. The present æra is too remote from that period, to enable us to ascertain the direct origin of the introduction of the contagious yellow fever into the West Indies; but on considering the general accounts of this circumstance, we are certainly inclined to believe, that in some instances it has been originally an imported disease. This opinion seems agreed upon, both by French, Spanish, and English authors, though they perhaps differ somewhat in respect of the particular sources from which it had its rise, and of the precise period of its introduction. At the same time, by considering the nature of the climate of the West India islands in general, we see good reason for supposing there frequently exists a concurrence of such circumstances, as give origin to the most malignant febrile distempers in other countries, and which, after the first impression, are propagated by contagion. The first statement seems, however, to confirm the correctness of the opinion already given, which tends to show, that the contagion of pestilence is not limited to any climate; it appears near to the line, and has been experienced far beyond the 60° of N. lat. towards the end of the last century.

On considering the influence of climate, we cannot be surprised to find, that plague, as well as every other sort of epidemic distemper, actually undergoes certain modifications from that power. This is demonstrated by what took place amongst the British troops in the West Indies during last war. The disease that raged so fatally amongst them in St Domingo, during 1796, 1797, and 1798, had its original source in Britain, perhaps in some of the manufacturing towns: the contagion was carried aboard the transports, where, in the course of a long voyage, it broke out in a virulent manner. But, though the same contagion can be easily traced, as a great cause of the mortality of the troops in the West Indies, the symptoms manifested by the fever before embarkation, during the voyage, and in the West Indies, were in many respects very dissimilar.

In treating of the methods best adapted for guarding against the effects of contagion, it is presumed, that an enumeration of such means as have been approved of by physicians of the greatest celebrity and experience in this branch of practice, or such as are suggested by the doctrine delivered in the foregoing pages, is all that can be necessary in this essay.

The efficacy of water, as a mean of destroying contagion, has not perhaps been sufficiently attended to in a practical point of view. Dr Smyth says, " That water possesses the same power as air, and may be employed with equal success in removing contagion from clothes or furniture." We have already investigated pretty fully this property of water; it now only remains for us to point out the facts that seem to apply more appositely to the present indication. In the hotels of European merchants, in towns on the Syrian coast, and in Egypt, &c. where the pestilence frequently breaks out, it is customary to have deep troughs, or buckets placed at the gates full of water; when the family is confined within, on purpose to preserve itself from the prevalent epidemic; every packet addressed to the individuals of it, and in short, all communication from without, must pass through this channel. It has accordingly been observed, that when this method is scrupulously attended to, there never has occurred an instance, where the plague has been introduced in this manner. Pugnet, in his Mémoires sur les Fievres, p. 185. treating of the different methods best adapted for purifying substances from the contagion of plague, observes, " La simple precaution de faire totalement plonger

dans le Nil les individus qui avaient eu les rapports les plus immediates, avec des sujets certainement infectés, celle de laver, ou de passer à la flamme, ou d'exposés à l'air les vêtements et autres choses à l'usage de ces mêmes personnes, n'a jamais trompé notre attente."

There is another strong corroboration of the efficacy of the antiloimic powers of water, related by the Baron de Tott of himself. Whilst he was employed in directing the fortification of the Dardanelles, the plague raged virulently amongst the labourers and others; he escaped it, and he imputes his exemption by having allowed himself to be occasionally drenched with rain, whenever a storm collected, instead of taking refuge under a tent, as others used to do; as from this last circumstance, he supposes the virulence of the contagion was much increased. The water-carriers of Egypt, are said likewise to be exempt from this disease; and we have been informed by a very intelligent observer, who practised as a navy surgeon during last war, that he found pledgets of linen, kept continually moist with cold water, were most effectual in the cure of a malignant sore that prevailed in the fleets, which was supposed to be contagious.

The utility of water as a powerful preventive of contagion, being determined by these and other facts already stated, it may be reasonably expected, that benefits the most important to society might be derived, by imitating the manner in which rain falls through the atmosphere, when that is wanting; it may likewise at any time be more directly and more copiously applied to the source of contagion in an artificial manner. Showers of rain may therefore be produced by means of water-engines; in this manner, water may be projected to a considerable distance, and thrown against the walls of houses, into narrow lanes, to the height of several feet above the roofs. This should be frequently performed, and each operation ought to be continued for a considerable length of time. The insides of the houses should be purified by the same means, or by white-washing, which certainly tends to the same effect. All sorts of furniture ought to be carefully scoured and washed, and kept immersed in water for some time. It ought likewise to be inculcated to the inhabitants, that their personal assistance in these operations is extremely conducive to their own safety: in the cool of the day, they may be employed in carrying water for the purposes we have specified, when a sufficient quantity cannot be obtained in the common reservoirs; nor should they be careful in preserving their clothes from being drenched.

Ablutions in this way, performed alternately with fumigations by any of the acids already mentioned, may be regarded as adding greatly to the antiloimic powers of both.

The external and internal use of oil is likewise recommended, as possessing almost specific powers; and there are many nostrums, whose efficacy depends entirely on this ingredient, sold in every country where the pestilence frequently appears. The dealers of oil in Egypt, are said to be exempted from the plague; and there is a fact mentioned by Baldwin, which seems to afford a strong confirmation of its antiloimic powers. In the space of five years there were two hundred and fifty people received into the hospital at Smyrna ill of plague; they were every one rubbed repeatedly over with warm oil, and all recovered; the practice is said to be prevalent all over Syria and Egypt.

The next means of prevention, and perhaps the most effectual, is to provide carefully a free circulation of the atmosphere, not through the streets of a city merely, but through every dwelling-house, stables and offices of every kind. It is not sufficient to open doors and windows for the admission of air: every attention must be paid to establish a current through the situations we have mentioned, and thereby prevent any portion of it becoming stagnant. Air admitted from without, into a room where there is no opposite egress, will only displace a corresponding quantity of that which is already within, and will therefore very speedily acquire similar qualities. It should also be generally advised, that fresh cool air is equally necessary for the recovery of the sick, as in preserving the health of those that are well. Hippocrates recommends a change of situation, where pestilential disorders are prevalent in a place. In proof of the salutary influence of the air in this respect, Paræus most pointedly recommends a change of air, whenever a person feels himself attacked with pestilence, this having a powerful effect in moderating its violence. In like manner, there is a fever very common in some places of Piedmont, for which the most effectual remedy is to respire the cool air of the Alps. Personal cleanliness is of the greatest importance in preserving health at all times. Cold sea-bathing, when urgent reasons do not forbid its use, should be advised during an epidemical season. The same injunction is no less necessary in a general way. The streets ought to be kept clean, and free of rubbish; for, independently of the loathsome appearance of dunghills, there is no kind of matter so well adapted to retain contagion as the heterogeneous substances of which they are composed; and probably, its virulence is frequently aggravated in consequence of the fermentation and decomposition of this species of fomites. Personal and general cleanliness must always be the precursory measures of preventive regulations. During the prevalence of any epidemical disorder, considerable attention must be paid to the regulation of the diet of those exposed to its influence; and an uniform tranquillity of mind must be as much as possible preserved, being assured, that there does not exist any common cause more apt to induce a susceptibility of the effects of contagion, than the temporary debility occasioned by an irregularity of the passions. Temperance in eating and drinking is likewise to be earnestly inculcated, and the diet to consist of as great a proportion of vegetables as former habits will permit: with this view, water, or well fermented small beer, should be considered as the most preferable beverage. Nothing can be more detrimental than an unrestricted use of spirits or of strong wines, especially if taken to excess. But care must be taken, in regulating all these matters, that they do not break in upon long-established habits; and that sort of regimen is to be used, that enables the functions of the body and mind to be enjoyed in the greatest vigour; for it must be remembered, that we cannot be too attentive in guarding against debility occasioned by abstemiousness, or the over-stimulating effects of luxury or a debauch. Almost every practical writer on the plague recommends the internal and external use of vinegar, as being a most effectual remedy in preventing the effects of its contagion. Diemerbroeck recommends a few tea-spoonfuls of it to be taken in the morning fasting; and Sylvius says he practised it with advantage. Its external use is notoriously known in the history of that preparation called the "three thieves' vinegar." Preservation from the power of contagion may be greatly assisted, by using mufflers, as originally proposed by Dr Hales ; or, what will answer the purpose equally well, is to have the mouth and nostrils covered with a double-folded piece of linen, or an handkerchief moistened with water or vinegar. By this contrivance, the air is allowed to pass into the lungs depurated from contagious matter, this being attracted and decomposed by the liquid with which the linen is moistened.

The kindling of fires in the streets of infected places, as a means of prevention, by purifying the air of noxious effluvia, has been employed from the earliest antiquity ; and it has been supposed to be productive of the most essential advantages, though, within a recent period, their beneficial effects have been questioned, and by many this practice has been considered not only as nugatory, but hurtful. It would seem, that in narrow lanes, and places where a free current of air is not continually passing, that fires may be useful in establishing its circulation ; and, in this respect, they will amply compensate for any loss of oxygen gas they may occasion. But from what has been already said on the effect of combustion, it is unnecessary to repeat here, that, in any other respect, this practice must be pernicious. The burning of aromatic gums and woods can hardly be supposed to answer any remarkably beneficial purpose: if conducted on a large scale, they must be considered in their effects as being similar to any other fuel; they may likewise envelope the contagious vapour in their own peculiar aroma, thereby disguising it, without abating its virulence.

The utility of matters carried about the person, as camphire, arsenic, &c. cannot be considered as having any other effect, than by their influence in amusing and fortifying the mind. The fumigation of houses, clothes, furniture, with nitric or oxymuriatic acid, has been found the most effectual method of decomposing contagion; and the latter may be regarded as possessing specific powers in destroying its properties.

Mercury has been much celebrated of late years for its antiloimic powers. If the authority of former times can be of consequence in adding to its reputation in this respect, which it has principally acquired by the experience of the present day, it will be found, in the *Commentaria de Rebus in Medicina gestis*, tom. i. that "In febribus malignis, mercurialia esse optima remedia," &c. In the works of Paræus, also, we find it recommended as a preventive against the plague, on the authority of Matthiolus; and Diemerbroeck affords us the following practical instance of its good effects in this way: A young lady, who happened to be under the influence of mercury for the cure of the venereal disease, when the plague raged with great violence in Holland, escaped its contagion, although three servants died of it in the house. Similar instances have been observed in hospitals in the case of typhus: there are also some papers in the Medical Journal, giving an account of different trials having been made with mercury as a preventive of yellow fever; and these reports seem rather favourable to its powers in this respect. At the same time, it is to be remarked, that Pugnet did not obtain any advantages from the effects of mercury as a preventive of pestilential contagion; and I have seen soldiers and others fully impregnated with mercury, for the cure of lues venerea, attacked with typhus contagion, which, in every instance, seemed to have been rendered thereby more severe. But, from the following facts on the use of issues as a mean of preventing the effects of contagion, we are induced to consider them as the most powerful remedy that can be employed with this intention.

In the history of the dreadful plague described by Procopius, he mentions, that those who had ulcers in their legs, or any part of their body, more generally escaped its contagion. Arculanus, who lived about the middle of the 15th century, makes a similar remark of a plague that appeared in his days, and recommends the formation of issues as the most efficacious preventive. In a plague that appeared in Leyden, 1564, Platerus perceived, that those who had issues were not affected by it, and that during its prevalence, a monk went about practising this method of prevention, which was then regarded as a charm, on account of the manner he used to bring on the suppuration: his method was to perforate the scrotum, and then to introduce a bit of black hellebore into the wound, which brought on a plentiful suppuration in a short time. Paræus includes issues in his class of preventive remedies, and recommends their utility with much precision and earnestness, and directs them to be formed on particular spots: his method is given in the following words: "Duo ulcera," says he, "tanquam excrementitiorum humorum quæ quotidie in nobis sensim congeruntur, rivos, appressis cauteriis aperiant; unum quidem in brachio dextro, paulo infra epomidem musculum; alterum trium sub genu digitorum intervallo parte externa cruris sinistri." And, in another chapter of the same treatise, he strongly dissuades against the healing of old sores in seasons when the plague prevails. To these we may add the authority of Diemerbroeck. Volney found, that the monks of Mar-Hannah El-Chouair in Syria were much less affected with the diseases of the country, than the peasantry amongst whom they lived; and they ascribed this superior degree of health to the effects of an issue which they always kept running in one of their arms.

In the works of Columella, *De Re Rustica*, the same remedy is recommended by him, and the operation described is pretty much the same, for preventing a contagious epidemic amongst cattle; and the utility of the same remedy has been attested by succeeding writers on agriculture. For a more particular account of the good effects of this remedy, we refer to the treatise of Muratori on the Management of the Plague: having entered fully into the discussion of its merits, he says, "Buon consiglio reputo io il non trascurare in occurrenza di peste questo preservativo, o almen questo tentativo, che che sentano in discredito d'esso alcuni moderni e seguaci delle ingegnose, ma non di rado stravaganti idée del Elmanzio, giacche la sperienza, piu venerabile di tutte le speculazione sembra commendarlo per utile."

An explanation of the manner how issues operate in preventing the effects of contagion merits a full consideration. At present, there does not exist even a tolerable theory on the subject. It does not appear probable, that they act by producing the elimination of peccant humours from the system: were that the case, the remedy would then prove more beneficial in the cure of epidemical diseases than in preventing them; as, in the latter case, the humours cannot be supposed to be vitiated, before the effects of the contagion manifest themselves. But, from many circumstances depending on its influence in other diseases, we are rather induced to suppose, that its good effects in the present case are entirely owing to its power in restraining an hurtful degree of plethora in the system. This opinion seems to be supported by what Larey experienced in the French army in Egypt: he found, that none of the soldiers that were wounded in the different engagements ever became affected with plague after their wounds began to suppurate. Dr Jackson likewise perceived, during the sickness which prevailed amongst the British troops in St Domingo, that the healing of an ulcer was often followed by a fatal flux or dangerous fever. It must be observed, however, that Pugnet refuses to sanction the utility of issues as a preventive of contagion.

Almost every treatise on the plague contains instances of sudden death, in consequence of inspiring the vapour arising from highly impregnated fomites. Paræus mentions, that he fell down in a state of insensibility, from having inhaled the odour arising from a pestilential bubo. Diemerbroeck relates an instance, where a man, exposed to the same kind of effluvia, fell down instantly to every appearance dead; luckily he remained neglected, and lay unburied for three days, when he gradually began to revive. The above case requires but a short commentary, and shows how cautious medical people ought to be in deciding on cases of asphyxia. It likewise affords a proof, that those who are suffocated by breathing the odour from pestilential fomites, should be considered precisely in the same state as those who are affected with asphyxia, by breathing any other noxious vapour.

THE END.

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